TSKgel GPC columns

GPC
GEL PERME
ATION
CHROMATO
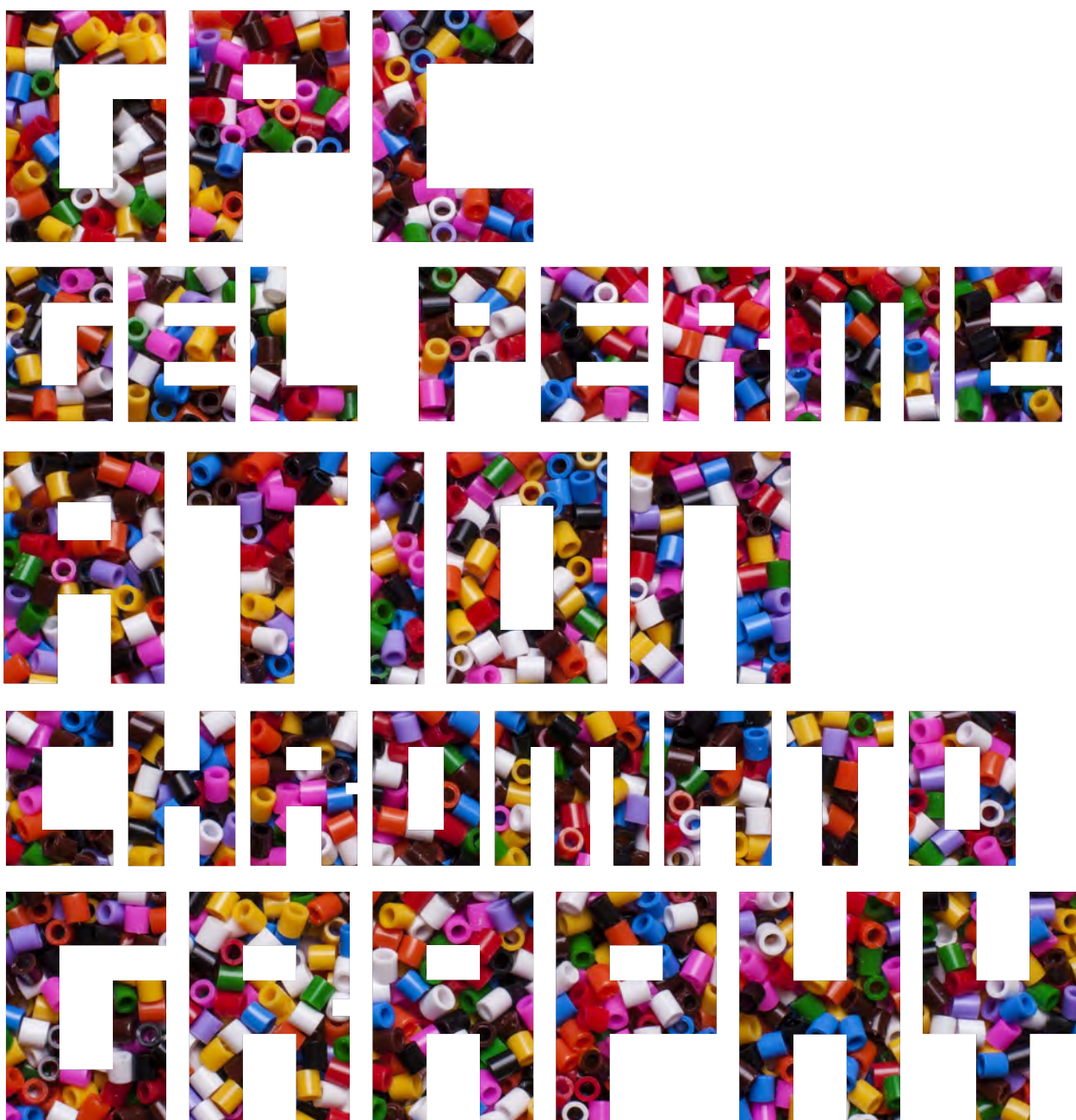GRAPHY

TOSOH BIOSCIENCE

ABOUT US

WITH A GLOBAL PERSPECTIVE.

TOSOH BIOSCIENCE GmbH, Separations Business Unit, Griesheim, is an acknowledged global leader in the field of bioseparations. Established as TosoHaas in 1987, the original joint venture between Tosoh Corporation of Japan and the Rohm and Haas Company, USA, has become synonymous with advanced products and quality support. In the year 2000, Tosoh Corporation acquired a 100% controlling interest changing the name to TOSOH BIOSEP. In the course of unifying all Tosoh affiliates, the new Brand Name Tosoh Bioscience evolved. Today, the two branches, Bioseparations and Diagnostics operate with the same name Tosoh Bioscience - Separations Business Unit and accordingly Diagnostics Business Unit. Tosoh manufacturing sites in Japan provide products to the sales and support subsidiaries in the U.S. and Europe, ensuring full global coverage. Over the last 40 years, TSKgel SW columns have become the worldwide industry standard for size exclusion chromatography of biomolecules.

1 ➤

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TOSOH HISTORY

1935	TOYO SODA MANUFACTURING CO., LTD. IS FOUNDED
1936	OPERATION OF NANYO MANUFACTURING COMPLEX BEGINS
1971	SCIENTIFIC INSTRUMENTS DIVISION DEVELOPS FIRST GPC COLUMN USING TSKgel
1974	HPLC COLUMN PLANT IS COMPLETED
1979	TOSOH DEVELOPS TOYOPEARL MEDIA
1983	TOSOH DEVELOPS HYDROPHOBIC INTERACTION MEDIA
1987	TOSOHAAS US STARTS OPERATING FROM MONTGOMERYVILLE
1989	TOSOHAAS GmbH STARTS OPERATING FROM STUTTGART
1995	TOSOH NANYO GEL FACILITY RECEIVES ISO 9001
2000/2001	FORMER TOSOHAAS US AND EUROPE OPERATIONS BECOME TOSOH BIOSEP, A 100% SUBSIDIARY OF TOSOH CORPORATION
2002/2003	ALL SCIENTIFIC AND DIAGNOSTIC SYSTEM RELATED COMPANIES IN EUROPE AND THE US ARE UNIFIED UNDER THE NEW NAME TOSOH BIOSCIENCE
2008	EcoSEC ,THE 7TH GENERATION GPC SYSTEM IS INTRODUCED
2009	TOSOH BIOSCIENCE GmbH CELEBRATES ITS 20TH ANNIVERSARY
2010	TOSOH CELEBRATES ITS 75TH YEAR IN BUSINESS AND CONTINUED RAPID EXPANSION IN CHINA
2011	TOSOH BIOSCIENCE CELEBRATES 40 YEARS OF OPERATION
2012	TOSOH RELEASES FIRST TOYOPEARL MIXED-MODE RESIN
2013	TOSOH RELEASES A HIGH CAPACITY PROTEIN A RESIN
2014	TOSOH BIOSCIENCE GmbH CELEBRATES ITS 25TH ANNIVERSARY
2015	TOSOH BIOSCIENCE GmbH MOVES TO GRIESHEIM, GERMANY

TOSOH BIOSCIENCE

Introduction

Size Exclusion Chromatography (SEC)

SEC separates molecules based on their size, or more precisely, their hydrodynamic volume. It is a well known technique for the separation of macromolecules like natural and synthetic polymers. When an aqueous eluent is used, SEC is also referred to as gel filtration chromatography (GFC). When an organic eluent is used, SEC is referred to as gel permeation chromatography (GPC). GPC is the method of choice for the characterization of polymer molecular weight and molecular weight distribution.

Tosoh Bioscience is a leading manufacturer of SEC/GPC columns and developed GPC instruments for the Asian market for more than 35 years. This brochure gives an overview over the Tosoh Bioscience GPC/SEC product portfolio for the separation of water and organic soluble polymers. The separation of proteins and biopolymers with silica based TSKgel SEC columns is not covered here.

Gel Permeation Chromatography (GPC)

GPC plays an important role in the characterization of organic-soluble polymers in the chemical and petrochemical industries. TSKgel GPC columns contain particles prepared from polystyrene crosslinked with divinylbenzene. Available products are grouped according to their relative lack of adsorptive properties and the speed of analysis.

Application Area: Organic-soluble polymers

Base material: polystyrene

Ultra-low adsorption columns with limited solvent range

- SuperHZ (high throughput)
- H_{XL} (conventional)

Low adsorption columns with expanded solvent range

- SuperH (high throughput)
- H_{HR} (conventional)

Application Area: Water- and organic-soluble polymers

Base material: polyvinyl

- Alpha
- SuperAW

These columns are ideal for industrial polymers soluble in water, buffers and many organic solvents.

Gel Filtration Chromatography (GFC)

GFC is popular among biochemists for the isolation of proteins, for the removal of aggregates, to desalt a protein sample, to separate nucleic acid fractions, or to characterize water-soluble polymers used in food products, paints, pharmaceutical preparations, etc. Available TSKgel products are classified by application area and particle composition.

These columns are ideal for industrial polymers, oligosaccharides, nucleic acids and small viruses using aqueous buffer or salt solutions as mobile phase. The PW_{XL}-CP columns are developed to facilitate SEC separation of cationic polymers under low salt conditions.

Application Area: Water-soluble polymers

Base material: polymethacrylate

- PW
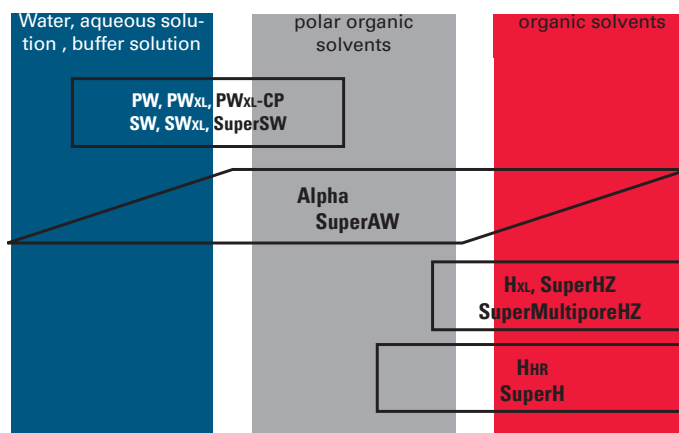- PW_{XL}
- PW_{XL}-CP

Application Area: Proteins and other biopolymers

Base material: silica

- SW
- SW_{XL}
- SuperSW

These columns are ideal for proteins and nucleic acids using an aqueous buffer as mobile phase.

➤ TSKgel SEC column: Solvents compatibility

Introduction

EcoSEC - THE WORLD'S FIRST SEMI-MICRO GPC/SEC SYSTEM FOR HIGH THROUGHPUT POLYMER ANALYSIS

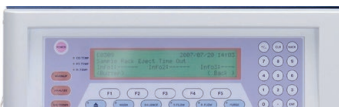ECOSEC FEATURES & BENEFITS

- Compact, low dead volume GPC/SEC system

- Outstanding performance at short analysis times

- Designed for semi-micro GPC, thereby saving solvent, waste disposal costs and analysis time

  Fully controlled by PSS WinGPC Unity software

detection for fast, high resolution, semi-micro GPC at temperatures below 60°C. It comprises a dual pump precision solvent delivery system, an automatic injector, a column oven and a high performance dual flow refractive index detector as standard (Figure 1). The EcoSEC can be equipped with additional detectors like UV, light scattering and viscosity detectors.

The EcoSEC GPC system is engineered to minimize extra column dead volume. This permits the use of smaller columns such as the TSKgel SuperMultiporeHZ semi-micro GPC columns. These columns are 4.6 mm ID x 15 cm L and consume about one sixth of the solvent compared to conventional systems and columns. In addition, run times are often half that of larger columns. At the same time semi-micro GPC often improves resolution and signal to noise levels.

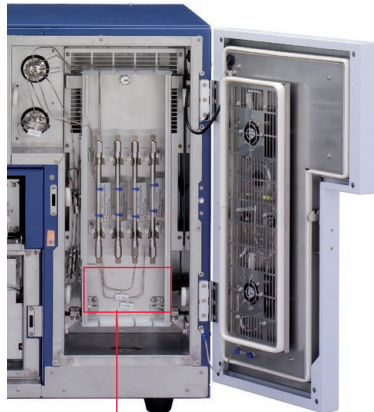EcoSEC is a compact, all-in-one system with refractive index

System Controller
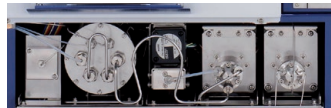Controls each device including automatic warm-up/shut-down function.

Degasser/ Purge Unit

Solvent Delivery System
Thermostatted dual pump system. Flow rate 10 – 2000 µl/min.

Optional UV detector

Auto Injector
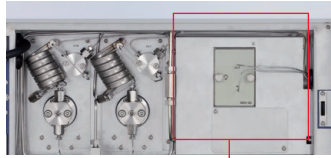Loop injection for up to 100 samples with 1 - 1500 µl injection volume.

Column Oven
Double layered, for up to 8 columns (7.8 mm ID x 30 cm L). Accommodates optional column switching valve. Temperature range from RT+10°C to 60°C.
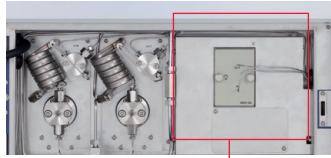
Refractive Index Detector
Low volume, dual flow detector with excellent baseline stability, integrated in thermostatted column compartment.

FIGURE 1

Choosing the appropriate SEC column

Choosing a TSKgel SEC column

Column type	Packing material	Sample type	Series	Features of series
H type	Styrene polymers	Synthetic polymers suitable for organic solvents	H_{XL}	General analysis, low adsorption
			H_{HR}	Analysis with various organic solvents
			SuperH	Quick and solvent-efficient analysis, high efficiency (semi-micro GPC column)
			SuperHZ	Quick, solvent-efficient analysis, high efficiency, low adsorption (semi-micro GPC column)
			Super MultiporeHZ	Calibration curve with high linearity
Alpha, SuperAW type	Hydrophilic polymers	Synthetic polymers suitable for organic solvents / Water-soluble synthetic polymers / Polysaccharides / Biopolymers (protein, DNA)	Alpha	Adsorption mode applicable to various types of polymer from water-soluble to organic-soluble
			SuperAW	Quick, low-solvent, and efficient (semi-micro SEC column) adsorption mode applicable from water-soluble to organic-soluble polymers
PW type	Hydrophilic polymers	Water-soluble synthetic polymers / Polysaccharides / Biopolymers (protein, DNA)	PW	Suitable for hydrophilic synthetic polymers
			PW_{XL}	High resolution
			PW_{XL}-CP	Suitable for cationic polymers
SW type	Silica	Biopolymers (protein, peptide)	SW	Highly hydrophilic and suitable for separation of proteins
			SW_{XL}	High resolution
			SuperSW	Efficient and solvent-saving (semi-micro SEC column)

Solvents supported by H-type columns

Column	Standard solvent (shipped with column)	Custom-order solvent	User-exchangeable solvent	Remarks
SuperHZ	THF		Benzene, toluene, xylene, dichloromethane, dichloroethane	
		Chloroform, DMF, cyclohexane, AK-225		
SuperH, H_{HR}	THF		Benzene, toluene, xylene, chloroform, dichloromethane, dichloroethane, DMF, DMSO, dioxane, n-hexane, cyclohexane, dodecane, NMP, quinoline, MEK, ODCB, trichlorobenzene, HFIP, HFIP/chloroform, pyridine, o-chlorophenol/chloroform, carbon tetrachloride, ethyl acetate, methanol/chloroform, acetone, ethanol, dimethylacetoamide, 1-chloronaphthalene, FC-113, trichloroethane	➤ All columns are shipped with THF as standard. ➤ Please note that once the solvent has been changed to a polar solvent such as DMF, the absorption characteristic may change even if THF is again used as the solvent.
H_{XL}	THF		Benzene, toluene, xylene, chloroform, dichloromethane (excluding G1000H), dichloroethane (excluding G1000H)	
		Chloroform	m-Cresol/chloroform, HFIP/chloroform (< 10% HFIP)	
		DMF	THF, toluene, DMSO, dioxane	
		Acetone	DMF, DMSO, dioxane, n-hexane, cyclohexane, dodecane, NMP, quinoline, MEK, ODCB, HFIP/chloroform, pyridine, carbon tetrachloride, ethyl acetate, FC-113	
		ODCB	Trichlorobenzene, 1-chloronaphthalene	

SuperH Series

<div align="right">Semi-micro GPC columns</div>

This series comprises semi-micro GPC columns (6.0 mm ID × 15 cm L) packed with styrene-divinylbenzene-type particulate gel. Analysis can be conducted in half the time taken by a conventional column (7.8 mm ID × 30 cm L), with solvent consumption 1/3 that of a conventional column, while achieving equal separation.
Four types of mixed column are provided for efficient analysis. The solvent can be changed to various organic solvents.

Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	6.0 mm ID × 15 cm L	
			Part #	TP/15cm
TSKgel SuperH1000	3	1×10^3	0017990	16,000
TSKgel SuperH2000	3	1×10^4	0017991	16,000
TSKgel SuperH2500	3	2×10^4	0017992	16,000
TSKgel SuperH3000	3	6×10^4	0017993	16,000
TSKgel SuperH4000	3	4×10^5	0017994	16,000
TSKgel SuperH5000	3	4×10^6	0017995	16,000
TSKgel SuperH6000	5	4×10^7 (Estimated)	0017996	10,000
TSKgel SuperH7000	5	4×10^8 (Estimated)	0017997	10,000
TSKgel SuperHM-L (mixed-bed)	3	4×10^6	0017998	16,000
TSKgel SuperHM-N (mixed-bed)	3	4×10^5	0017999	16,000
TSKgel SuperHM-M (mixed-bed)	3	4×10^6	0018000	16,000
TSKgel SuperHM-H (mixed-bed)	3 & 5	4×10^8 (Estimated)	0018001	16,000

Guard column

| Description	Part #	Column size	Remarks
TSKguardcolumn SuperH-L	0018002	4.6 mm ID × 3.5 cm L	For SuperH1000 – SuperH4000
TSKguardcolumn SuperH-H	0018003	4.6 mm ID × 3.5 cm L	For SuperH5000 – SuperH7000, SuperHM

Reference column*

| Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID × 15 cm L

Standard solvent (shipped with the columns): THF

* The reference column is used for the reference flow line of the refractive index detector of the EcoSEC GPC system, the column cannot be used for GPC separations.

Calibration curves for TSKgel SuperH Series

① SuperH7000
② SuperH6000
③ SuperH5000
④ SuperH4000
⑤ SuperH3000
⑥ SuperH2500
⑦ SuperH2000
⑧ SuperH1000
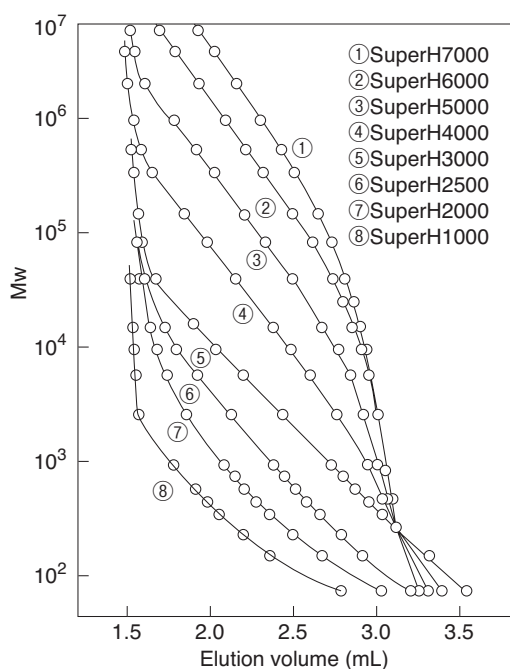
Column: TSKgel SuperH Series (6.0 mm ID × 15 cm L)
Eluent: THF
Flow rate: 0.6 mL/min
Temp.: 25 °C
Detection: UV (254 nm)
Sample: Standard polystyrene

① SuperHM-H
② SuperHM-M
③ SuperHM-N
④ SuperHM-L
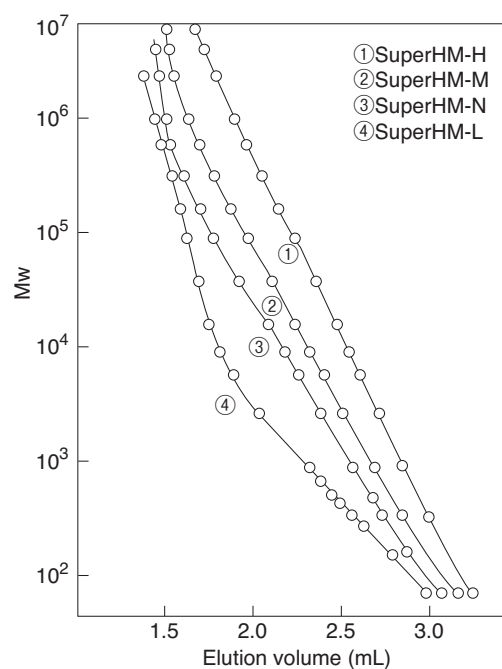
SuperHZ Series

Semi-micro GPC columns

This series comprises semi-micro SEC columns (4.6 mm ID × 15 cm L and 6.0 mm ID × 15 cm L) packed with a particulate gel based on styrene divinylbenzene. Analysis can be conducted in half the time taken by a conventional column (7.8 mm ID × 30 cm L), with solvent consumption 1/6 that of a conventional column (4.6 mm ID × 15 cm L), while achieving equal separation. All columns are shipped with THF as standard solvent.

➤ Analytical column (4.6 mm ID)

Description	Particle size µm	Exclusion limit (Polystyrene)	4.6 mm ID × 15 cm L	
			Part #	TP/15cm
TSKgel SuperHZ1000	3	1×10^3	0019309	16,000
TSKgel SuperHZ2000	3	1×10^4	0019310	16,000
TSKgel SuperHZ2500	3	2×10^4	0019311	16,000
TSKgel SuperHZ3000	3	6×10^4	0019312	16,000
TSKgel SuperHZ4000	3	4×10^5	0019313	16,000
TSKgel SuperHZM-N (mixed-bed)	3	7×10^5	0019660	16,000
TSKgel SuperHZM-M (mixed-bed)	3 & 5	4×10^6	0019662	16,000
TSKgel SuperHZM-H (mixed-bed)	10	4×10^8 (Estimated)	0019664	19,000

With SuperHZ Series columns (4.6 mm ID), use Tosoh's GPC **only** system HLC-8320GPC. Note that these columns may not operate at maximum efficiency in conjunction with an ordinary HPLC system.

➤ Guard column

Description	Part #	Column size	Remarks
TSKguardcolumn SuperHZ-L	0019314	4.6 mm ID × 2.0 cm L	For SuperHZ1000 – 4000, M-N, -M
TSKguardcolumn SuperHZ-H	0019668	4.6 mm ID × 2.0 cm L	For SuperHZM-H

➤ Analytical column (6.0 mm ID)

Description	Particle size µm	Exclusion limit (polystyrene)	6.0 mm ID × 15 cm L	
			Part #	TP/15cm
TSKgel SuperHZ1000	3	1×10^3	0019302	16,000
TSKgel SuperHZ2000	3	1×10^4	0019303	16,000
TSKgel SuperHZ2500	3	2×10^4	0019304	16,000
TSKgel SuperHZ3000	3	6×10^4	0019305	16,000
TSKgel SuperHZ4000	3	4×10^5	0019306	16,000
TSKgel SuperHZM-N (mixed-bed)	3	7×10^5	0019661	16,000
TSKgel SuperHZM-M (mixed-bed)	3 & 5	4×10^6	0019663	16,000
TSKgel SuperHZM-H (mixed-bed)	10	4×10^8 (Estimated)	0019665	19,000

With SuperHZ Series columns (6.0 mm ID), use Tosoh's GPC **only** system HLC-8320GPC or a HPLC system for semi-micro GPC columns. Note that these columns may not operate at maximum efficiency in conjunction with an ordinary HPLC system.
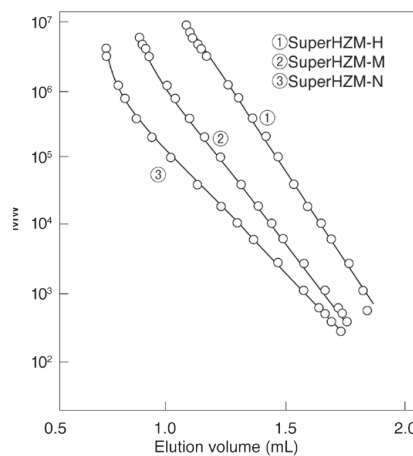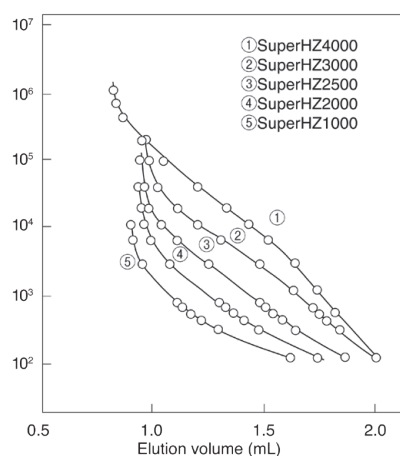
➤ Guard column

Description	Part #	Column size	Remarks
TSKguardcolumn SuperHZ-L	0019666	4.6 mm ID × 3.5 cm L	For SuperHZ1000 – 4000, M-N, -M
TSKguardcolumn SuperHZ-H	0019667	4.6 mm ID × 3.5 cm L	For SuperHZM-H

➤ Reference column*

Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID × 15 cm L

Standard solvent (shipped with the columns): THF

## Calibration curves for TSKgel SuperHZ Series

①SuperHZ4000
②SuperHZ3000
③SuperHZ2500
④SuperHZ2000
⑤SuperHZ1000

Column: 4.6 mm ID × 15 cm
Eluent: THF
Flow rate: 0.35 mL/min
Detection: UV (254 nm)
Temp.: 25 °C
Sample: Standard polystyrene

①SuperHZM-H
②SuperHZM-M
③SuperHZM-N

Column: 4.6 mm ID × 15 cm
Eluent: THF
Flow rate: 0.35 mL/min
Detection: UV (254 nm)
Temp.: 25 °C
Sample: Standard polystyrene

SuperHZ Series

Separation of epoxy resin
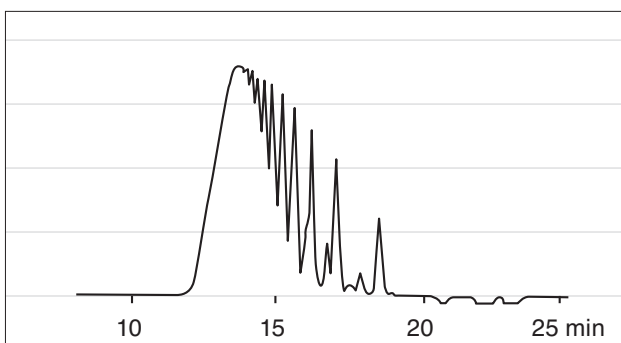
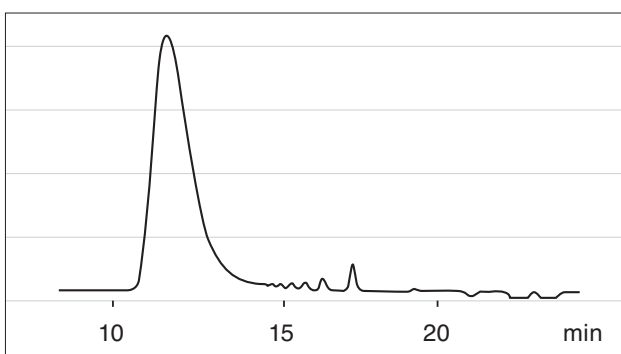Column: TSKgel SuperHZ4000 + 3000 + 2000 + 2000
                   (4.6 mm ID × 15 cm × 4 in series)
Eluent: THF
Flow rate: 0.35 mL/min
Detection: RI
Temperature: 40 °C
Injection volume: 10 µL (1.0 g/L)

Comparison of SuperHZ Series and H$_{HR}$ Series
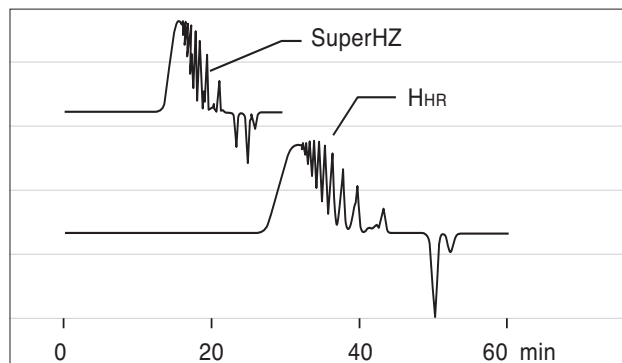
Column: TSKgel SuperHZ4000 + 3000 + 2500 + 2000
                   (4.6 mm ID × 15 cm L × 4 in series)
                   TSKgel G4000 + 3000 + 2500 + 2000H$_{HR}$
                   (7.8 mm ID × 30 cm L × 4 in series)
Eluent: THF
Flow rate: 0.35 mL/min (SuperHZ), 1.0 mL/min (H$_{HR}$)
Detection: RI
Temperature: 40 °C
Injection volume: 2 µL (SuperHZ), 20 µL (H$_{HR}$), 0.5 g/L
Sample: Epoxy resin

Separation of polysulfone
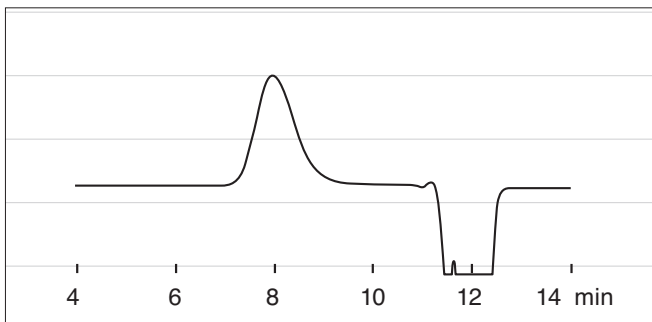

Column: TSKgel SuperHZ4000 + 3000 + 2000 + 2000
                   (4.6 mm ID × 15 cm L × 4 in series)
Eluent: THF
Flow rate: 0.35 mL/min
Detection: RI
Temperature: 40 °C
Injection volume: 10 µL (0.5 g/L)

Separation of polycarbonate
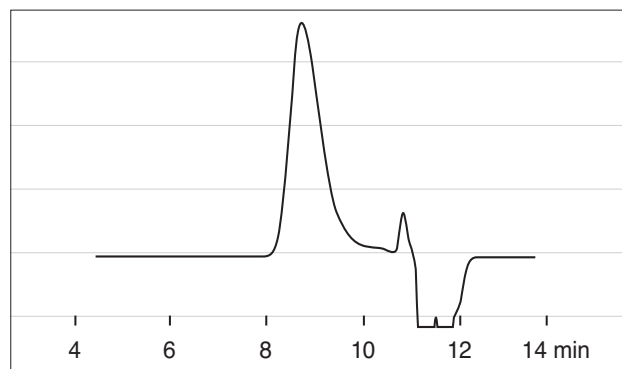
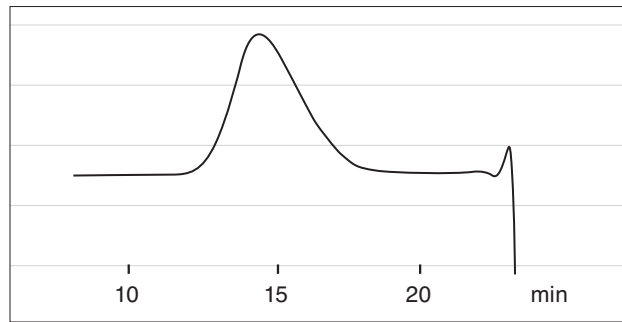Column: TSKgel SuperHZM-H
                   (4.6 mm ID × 15 cm L × 2 in series)
Eluent: THF
Flow rate: 0.35 mL/min
Detection: RI
Temperature: 40 °C
Injection volume: 10 µL (0.5 g/L)

Separation of polystyrene (SRM706)

Column: TSKgel SuperHZM-H
                   (4.6 mm ID × 15 cm L × 2 in series)
Eluent: THF
Flow rate: 0.35 mL/min
Detection: RI
Temperature: 40 °C
Injection volume: 10 µL (0.5 g/L)

Separation of acrylic resin

Column: TSKgel SuperHZM-H
                   (4.6 mm ID × 15 cm L × 4 in series)
Eluent: THF
Flow rate: 0.35 mL/min
Detection: RI
Temperature: 40 °C
Injection volume: 10 µL (0.5 g/L)

TOSOH BIOSCIENCE

TOSOH

SuperMultiporeHZ Series

Multipore semi-micro GPC columns

This series comprises ultra-high-performance organic SEC columns with low dead volume (4.6 mm I.D. × 15 cm L) featuring a multipore with a wide pore distribution in each particle. The use of the multipore ensures that the calibration curves have excellent linearity. Chromatograms are free of irregularities because the calibration curves contain no inflection points.
Three molecular weight ranges are available.

➢ Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	4.6 mm ID × 15 cm L	
			Part #	TP/15cm
TSKgel SuperMultiporeHZ-H	6	4.0×10^7 (Estimated)	0021885	11,000
TSKgel SuperMultiporeHZ-M	4	2.0×10^6	0021488	16,000
TSKgel SuperMultiporeHZ-N	3	1.2×10^5	0021815	20,000

➢ Guard column

| Description	Part #	Column size	Remarks
TSKguardcolumn SuperMPHZ-H	0021886	4.6 mm ID × 2.0 cm L	For H grade
TSKguardcolumn SuperMPHZ-M	0021489	4.6 mm ID × 2.0 cm L	For M grade
TSKguardcolumn SuperMPHZ-N	0021816	4.6 mm ID × 2.0 cm L	For N grade

➢ Reference column*

| Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID × 15 cm L

Standard solvent (shipped with the columns): THF

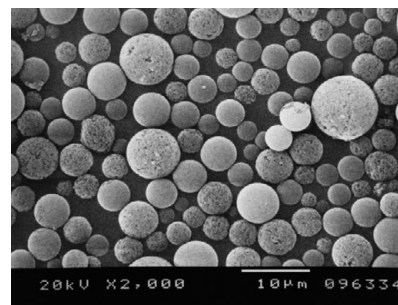## SEM photographs of TSKgel SuperMultiporeHZ and Commercial mixed-bed column

The SuperMultiporeHZ Series is packed with monodispersed particles of uniform diameter, which results in a high theoretical plate number.
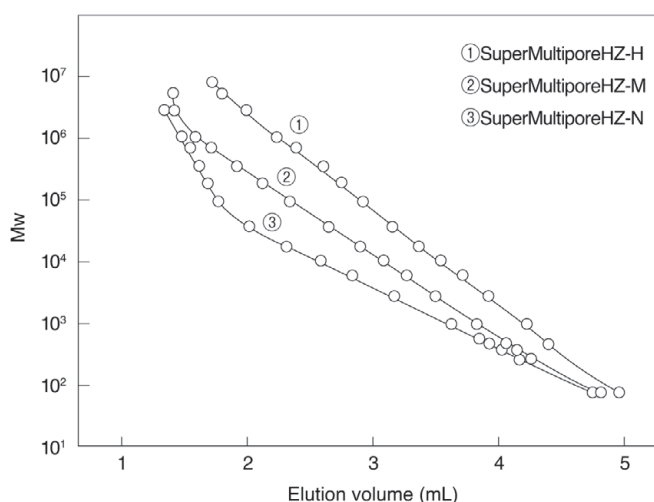

20kU X2,000   10µm 096334

TSKgel SuperMultiporeHZ-N

20kU X2,000   10µm 096334

TSKgel SuperMultiporeHZ-M


20kU X2,000   10µm 096334
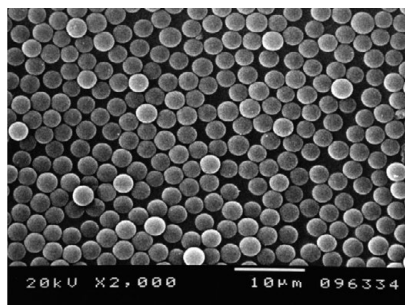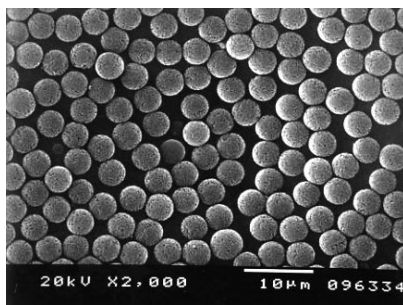
Commercial product (mixed-bed)

TSKgel SuperMultiporeHZ Series: Calibration curves

The calibration curves of the SuperMultiporeHZ Series show excellent linearity.

① SuperMultiporeHZ-H
② SuperMultiporeHZ-M
③ SuperMultiporeHZ-N

Column:	4.6 mm I.D.×15 cm L	Detection:	UV(254 nm)
Eluent:	THF	Temp.:	25 °C
Flow rate:	0.35 mL/min	Sample:	Standard polystyrene

Comparison of pore size distribution

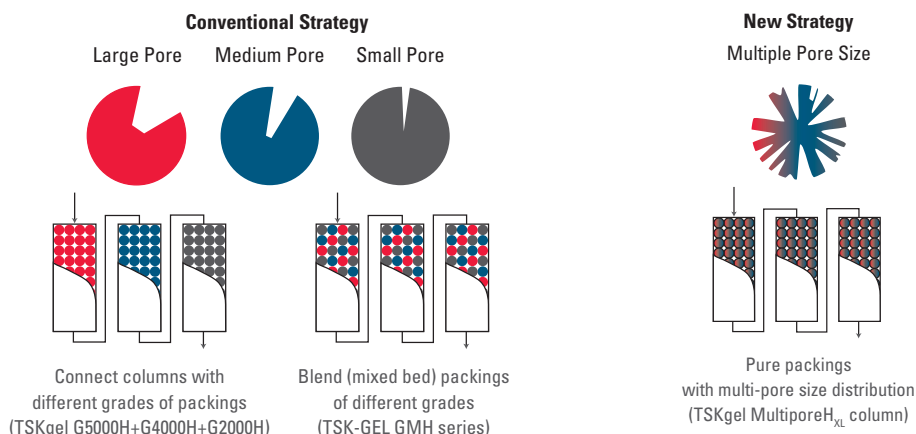Commercial mixed-type column

SuperMultiporeHZ-M
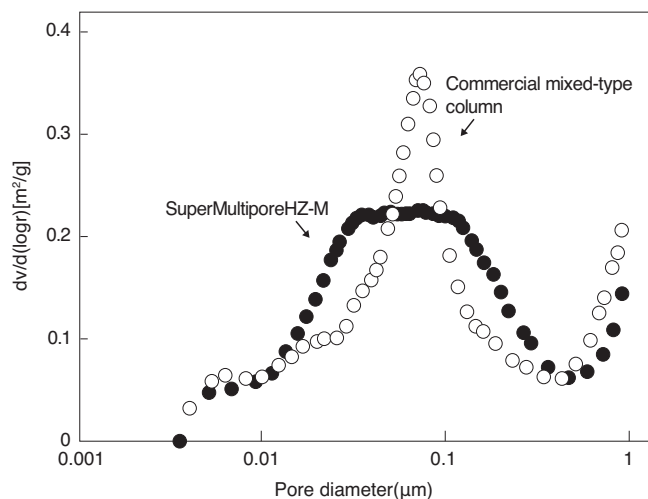
SuperMultiporeHZ Series

Multipore semi-micro GPC columns

Generally, SEC packing materials have a comparatively narrow pore distribution. When conducting analysis of synthetic polymers with relatively wide molecular weight distribution, it is necessary to use several connected columns containing packing materials with different pore diameters, or a single column containing several packing materials of different pore diameters (mixed bed column). The calibration curves of these columns show deviations or level differences (inflection points) where the calibration curves of packing materials with different pore diameters meet. This causes irregularities in the resulting chromatograms. In contrast, multipore-type packing materials have a very wide range of molecular weight fractions because each particle has pores of various diameters. The calibration curves show excellent linearity and no inflection points, and accurate analysis of molecular weight may be achieved.
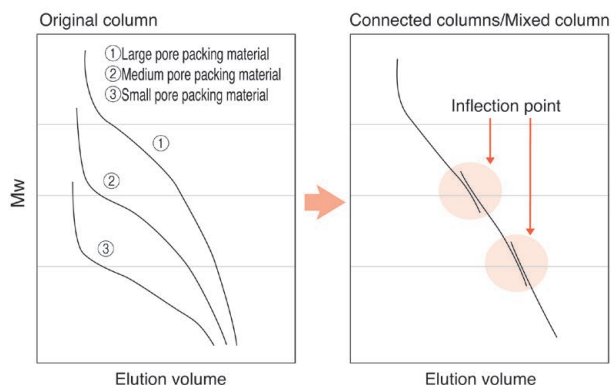
Schematics of SEC packing materials

Conventional Strategy

Large Pore   Medium Pore   Small Pore

Connect columns with
different grades of packings
(TSKgel G5000H+G4000H+G2000H)

Blend (mixed bed) packings
of different grades
(TSK-GEL GMH series)

New Strategy

Multiple Pore Size

Pure packings
with multi-pore size distribution
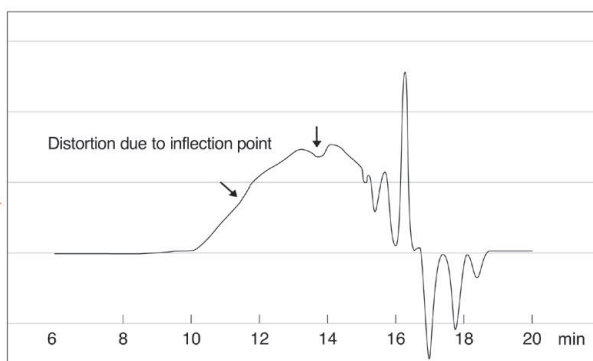(TSKgel MultiporeH$_{XL}$ column)

Calibration curve and chromatogram irregularities

If columns containing packing materials with different pore diameters are connected, or a mixed-type column is used, inflection points appear on the calibration curve. This may cause irregularities in the chromatogram.
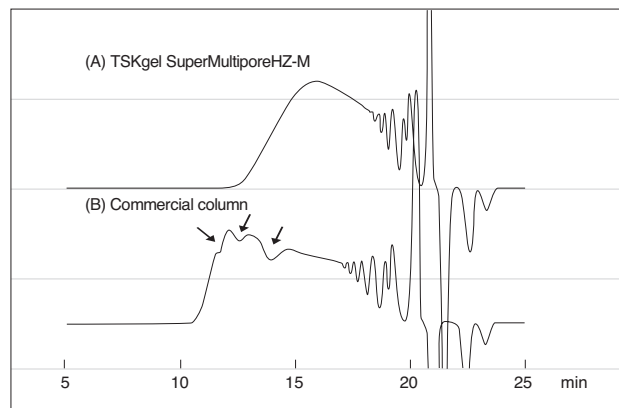
Calibration curve of conventional SEC column

Original column
① Large pore packing material
② Medium pore packing material
③ Small pore packing material

Mw

Elution volume

Connected columns/Mixed column

Inflection point

Elution volume

Chromatogram from mixed-type column

Distortion due to inflection point

6   8   10   12   14   16   18   20   min

Separation of phenol resin

(A) TSKgel SuperMultiporeHZ-M

(B) Commercial column

5   10   15   20   25   min
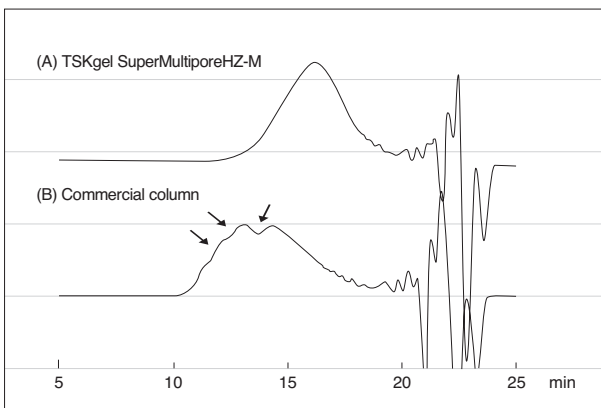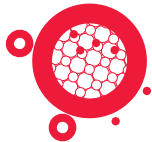
Column: (A) SuperMultiporeHZ-M (4.6 mm ID × 15 cm L × 4 in series)
           (B) Commercial column (4.6 mm ID × 15 cm L × 4 in series)
Eluent: THF   Temperature: 40 °C
Flow rate: 0.35 mL/min   Detection: RI
Sample: Phenolic resin 0.3%, 10 µL

Separation of acryl polymer

(A) TSKgel SuperMultiporeHZ-M

(B) Commercial column

5   10   15   20   25   min

Column: (A) SuperMultipore HZ-M (4.6 mm ID × 15 cm L × 4 in series)
           (B) Commercial column (4.6 mm ID × 15 cm L × 4 in series)
Eluent: THF   Temperature: 40 °C
Flow rate: 0.35 mL/min   Detection: RI
Sample: Acrylic resin 0.3% 10 µL

TOSOH BIOSCIENCE

TOSOH

MultiporeHXL-M

Multipore linear GPC columns

Columns of the MultiporeHXL-M Series contain packing material (multipore gel) which features a wide distribution of pore diameters in each particle, unlike conventional SEC packing materials. The calibration curves of these columns show improved linearity (compared with those of conventional columns) and no inflection points. These characteristics ensure a more accurate analysis of molecular weight distribution.

Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	7.8 mm ID × 30 cm	
			Part #	TP/30cm
TSKgel MultiporeHXL-M	5	2×10^6	0018403	16,000

Guard column

Description	Part #	Column size	Remarks
TSKguardcolumn MP(XL)	0018404	6.0 mm ID × 4 cm	For MultiporeHXL-M

Reference column*

| Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID ×15 cm

Standard solvent (shipped with the columns): THF
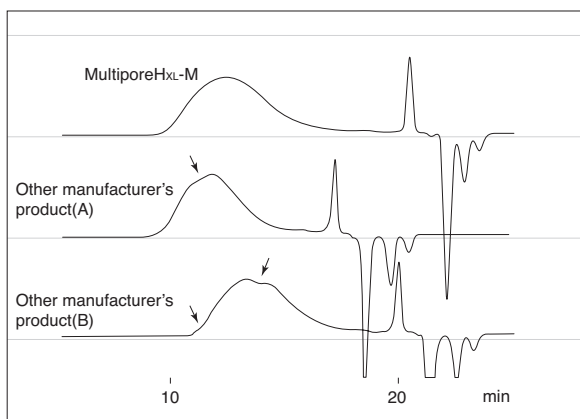
TSKgel MultiporeHXL-M
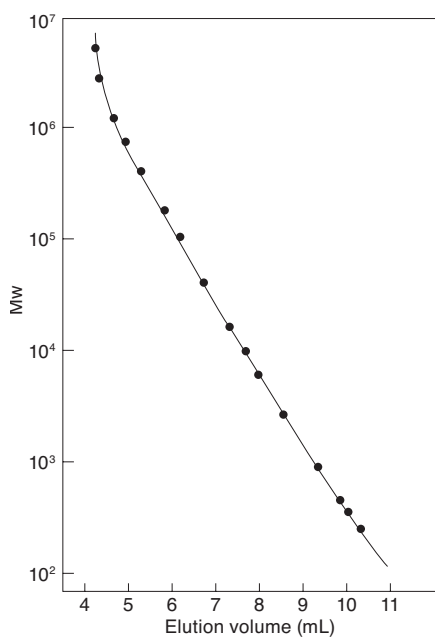
Column: TSKgel MultiporeHXL-M
(7.8 mm ID × 30 cm)
Solvent: THF
Flow rate: 1.0 mL/min
Temp.: 25 °C
Detection: UV (254 nm)
Sample: Standard polystyrene

Separation of epoxy resin by TSKgel MultiporeHXL-M: Comparison with linear columns from other manufacturers
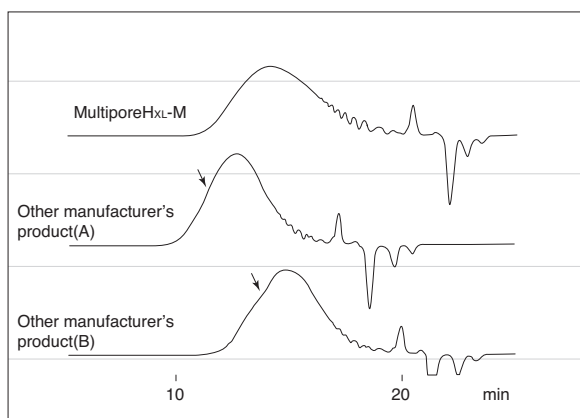
Column: TSKgel MultiporeHXL-M, (7.8 mm ID × 30 cm × 2 in series)
Eluent: THF   Temperature: 40 °C
Flow rate: 1.0 mL/min   Detection: RI

Separation of acrylic resin by TSKgel MultiporeHXL-M, compared with linear columns from other manufactures

Column: TSKgel MultiporeHXL-M, (7.8 mm ID × 30 cm × 2 in series)
Eluent: THF   Temperature: 40 °C
Flow rate: 1.0 mL/min   Detection: RI

HXL-Series

High performance GPC columns

This series comprises high-speed SEC columns (7.8 mm ID × 30 cm) packed with 5 µm and 9 µm styrene divinylbenzene gels.

Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	7.8 mm ID × 30 cm L	
			Part #	TP/30cm
TSKgel G1000HXL	5	1×10^3	0016131	16,000
TSKgel G2000HXL	5	1×10^4	0016134	16,000
TSKgel G2500HXL	5	2×10^4	0016135	16,000
TSKgel G3000HXL	5	6×10^4	0016136	16,000
TSKgel G4000HXL	5	4×10^5	0016137	16,000
TSKgel G5000HXL	9	4×10^6	0016138	14,000
TSKgel G6000HXL	9	4×10^7 (Estimated)	0016139	14,000
TSKgel G7000HXL	9	4×10^8 (Estimated)	0016140	14,000
TSKgel GMHXL-L (mixed-bed)	5	4×10^6	0016652	16,000
TSKgel GMHXL (mixed-bed)	9	4×10^8 (Estimated)	0016141	14,000

Guard column

Description	Part #	Column size	Remarks
TSKguardcolumn HXL-L	0007113	6.0 mm ID × 4 cm L	For G1000HXL – G4000HXL
TSKguardcolumn HXL-H	0013727	6.0 mm ID × 4 cm L	For G5000HXL – GMHXL, GMHXL-L

Reference column*

Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID × 15 cm L

Standard solvent (shipped with the columns): THF

Calibration curves for HXL Series

① GMHXL
② GMHXL-L
③ G7000HXL
④ G6000HXL
⑤ G5000HXL
⑥ G4000HXL
⑦ G3000HXL
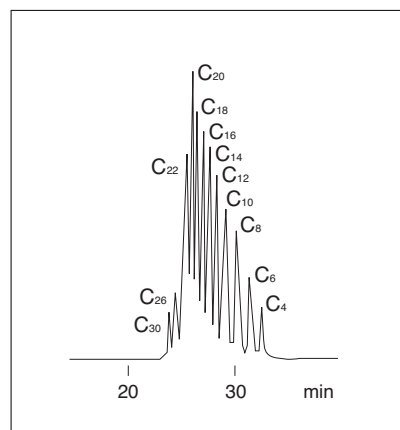⑧ G2500HXL
⑨ G2000HXL
⑩ G1000HXL
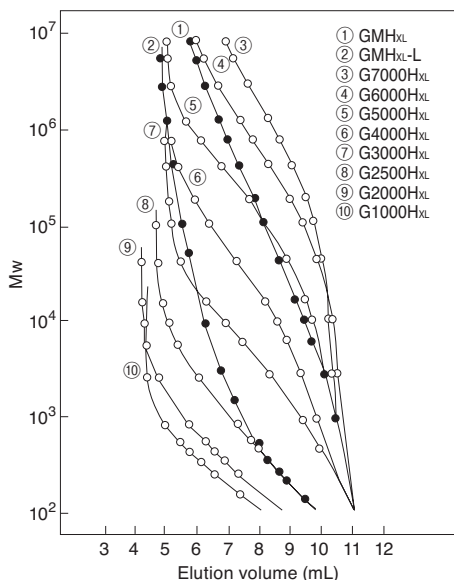
Column: TSKgel HXL Series
            (7.8 mm I.D. × 30 cm L)
Eluent: THF
Flow rate: 1.0 mL/min
Detection: UV (254 nm)
Temp.:   25 °C
Sample: Standard polystyrene

Separation of epoxy resin
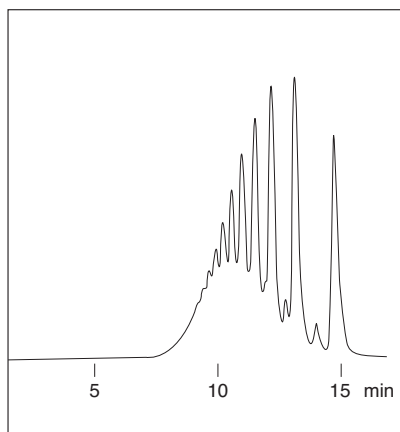
Column: TSKgel G2500HXL
            (7.8 mm ID × 30 cm L × 2 in series)
Eluent: THF
Flow rate: 1.0 mL/min
Detection: RI

Separation of fatty acids

Column: TSKgel G2500HXL
            (7.8 mm ID × 30 cm L × 2 in series)
Eluent: THF
Flow rate: 1.0 mL/min
Detection: RI

TOSOH BIOSCIENCE

HHR-Series

Solvent compatible GPC columns

This series comprises high-speed SEC columns (7.8 mm ID × 30 cm L) packed with 5 μm styrene divinylbenzene-type gel. The columns feature excellent solvent compatibility and durability. The solvent can be changed to various organic solvents.

Analytical column

Description	Particle size μm	Exclusion limit (Polystyrene)	7.8 mm ID × 30 cm L	
			Part #	TP/30cm
TSKgel G1000HHR	5	1×10^3	0017352	16,000
TSKgel G2000HHR	5	1×10^4	0017353	16,000
TSKgel G2500HHR	5	2×10^4	0017354	16,000
TSKgel G3000HHR	5	6×10^4	0017355	16,000
TSKgel G4000HHR	5	4×10^5	0017356	16,000
TSKgel G5000HHR	5	4×10^6	0017357	16,000
TSKgel G6000HHR	5	4×10^7 (Estimated)	0017358	16,000
TSKgel G7000HHR	5	4×10^8 (Estimated)	0017359	16,000
TSKgel GMHHR-L (mixed-bed)	5	4×10^6	0017362	16,000
TSKgel GMHHR-N (mixed-bed)	5	4×10^5	0018055	16,000
TSKgel GMHHR-M (mixed-bed)	5	4×10^6	0017392	16,000
TSKgel GMHHR-H (mixed-bed)	5	4×10^8 (Estimated)	0017360	16,000

Guard column

| Description	Part #	Column size	Remarks
TSKguardcolumn HHR-L	0017368	6.0 mm ID × 4 cm L	For G1000HHR – G4000HHR
TSKguardcolumn HHR-H	0017369	6.0 mm ID × 4 cm L	For G5000HHR – GMHHR-L, -N, -M, -H

Reference column*

Description	Part #	Column size
TSKgel SuperH-RC	0018004	6.0 mm ID × 15 cm L

Standard solvent (shipped with all analytical columns): THF

Calibration curves for HHR Series
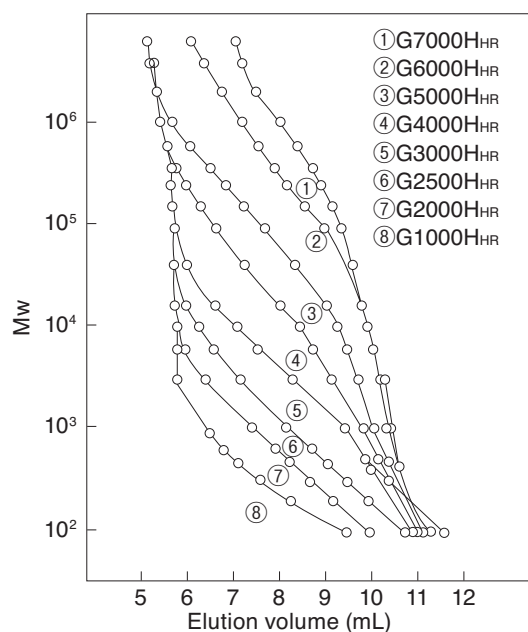
Column: TSKgel HHR Series (7.8 mm ID × 30 cm L)
Flow rate: 1.0 mL/min
Detection: UV (254 nm)
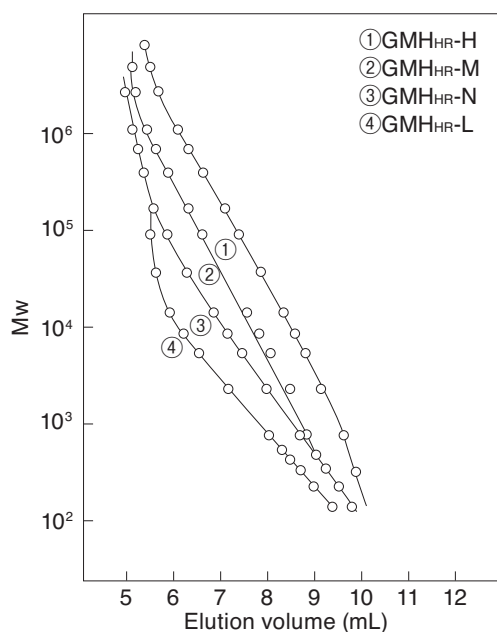
Eluent: THF
Temp.:   25 °C
Sample: Standard polystyrene

H-HT Series

High temperature GPC columns

For use in high temperature SEC applications, these columns (7.8 mm ID × 30 cm L), packed with styrene divinylbenzene-type gel, feature excellent solvent exchangeability and durability with temperature variation.

◢ Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	7.8 mm ID × 30 cm L	
			Part #	TP/30cm
TSKgel GMHHR-H(30)HT (mixed-bed)	30	4 × 10⁸ (Estimated)	0018391	≥ 4,000
TSKgel GMHHR-H(20)HT (mixed-bed)	20	4 × 10⁸ (Estimated)	0018392	≥ 6,000
TSKgel GMHHR-H(S)HT (mixed-bed)	13	4 × 10⁸ (Estimated)	0018393	≥ 8,000

Standard solvent (shipped with all analytical columns): ODCB

◢ Guard column

| Description	Particle size µm	Part #	Column size
TSKgel Guard Column for TSKgel GMHHR-H(S) HT & GMHXL-HT	30	0018397	7.5 mm ID × 7.5 cm L

◢ Accessories

Description	Part #
Sample vial, transparent, 10 mL, 30/pk (PTFE cover)	0023809
Aluminum sheets, 30 mm, square, 100/pk	0023810
Stainless steel mesh, 26 µm, 50 mm, square, 100/pk	0023811
Stainless steel mesh, 96 µm, 50 mm, square, 100/pk	0023812

Calibration curves for high temperature
GPC mixed column series

Separation of polyethylene

◇ TSKgel GMHHR-H(S)HT
■ TSKgel GMHXL-HT
▲ TSKgel GMHHR-H(30)HT
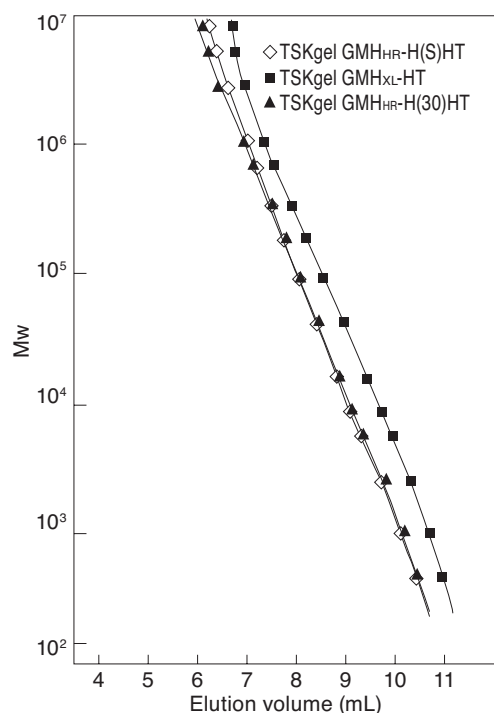
Column: TSKgel GMHHR-H (S) HT
             TSKgel GMHXL-HT
             TSKgel GMHHR-H (30) HT
Eluent: ODCB (o-dichlorobenzene)
Flow rate: 1.0 mL/min
Temperature: 135 °C
Detection: RI
Sample: Standard polystyrene
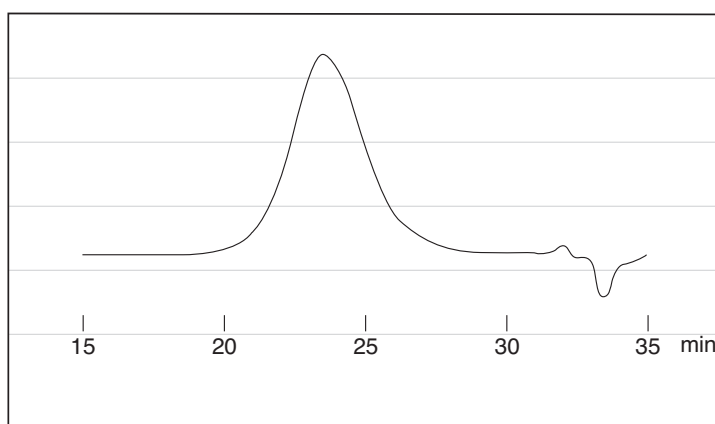
Column: TSKgel GMHHR-H (20) HT (7.8 mm ID × 30 cm L × 3 in series)
Eluent: ODCB
Flow rate: 1.0 mL/min
Temperature: 145 °C
Detection: RI
Sample: SRM1475

H-HT-Series

High temperature GPC columns

TSKgel H series columns are recommended for the analysis of organic-soluble polymers and are packed with spherical particles composed of polystyrene cross-linked with divinylbenzene (PS-DVB). The "GM" prefix denotes a column packed with particles of different pore sizes blended to provide an extended linear calibration curve. The TSKgel HT series are for high temperature applications (≤ 140 °C) while the TSKgel HT2 columns are used in ultra-high temperature (up to 220 °C) applications.

The figure below demonstrates the performance stability of the TSKgel GMHHR-H HT columns compared to other commercially available high temperature GPC columns during repetitive temperature changes.

The TSKgel HHR HT columns and two commercially available high temperature GPC columns were subjected to drastic changes in temperature by raising the temperature for 2 hours followed by lowering the temperature for two hours for a total of 60 cycles. The number of theoretical plates was shown to remain constant for the TSKgel HHR HT columns and to decrease by 15% for the two commercially available high temperature GPC columns; thus revealing the superior performance stability of the TSKgel HHR HT columns.

Table 2 lists the attributes of the TSKgel HT columns which are for high temperature applications up to 140 °C.
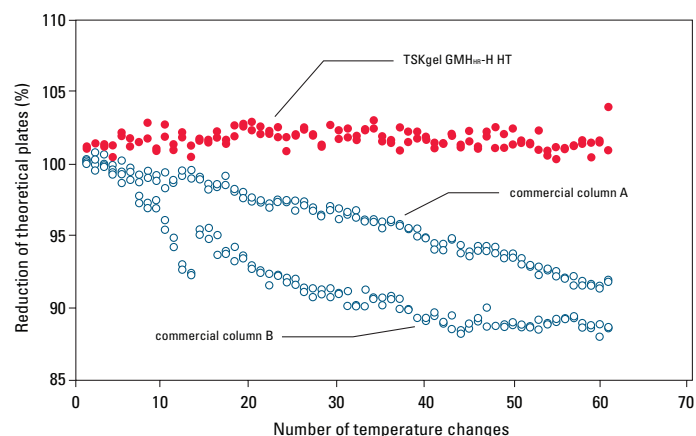
Durability of TSKgel HHR HT columns compared to two commercially available high temperature GPC columns

Column: TSKgel GMHHR-H HT, 5 µm, 7.8 mm ID × 30 cm L × 2
Mobile phase: ODCB with 0.05% BHT
Flow rate: 1 mL/min
Detector: RI (EcoSEC High Temperature GPC System);
Temperature: 40 to 145 ˚C

H-HT2-Series

Ultra-high temperature GPC columns

The TSKgel column series also includes four columns for the analysis of polymers at ultra-high temperatures (up to 220 °C). The TSKgel HT2 columns are specifically designed for the analysis of organic-soluble polymers at extremely elevated temperatures. The attributes of the TSKgel HT2 column series are listed below.

⇒ Analytical column

Description	Particle size µm	Exclusion limit (Polystyrene)	7.8 mm ID × 30 cm L	
			Part #	TP/30 cm
TSKgel GMHH_HR-H(20) HT2	20	4.0×10^8	0022888	≥ 6,000
TSKgel GMHH_HR-H(30) HT2	30	4.0×10^8	0022887	≥ 4,000
TSKgel GMHH_HR-H(S) HT2	20	4.0×10^8	0022889	≥ 8,000
TSKgel G2000H_HR-H HT2	20	1.0×10^4	0022890	≥ 6,000

⇒ Guard column

Description	Particle size µm	Part #	Column size
TSKgel Guard Column for TSKgel GMH_HR-H (20) HT2 & GMH_HR-H(30) HT2	30	0022891	7.5 mm ID × 7.5 cm L
TSKgel Guard Column for TSKgel GMH_HR-H(S) HT2	13	0022892	7.5 mm ID × 7.5 cm L

⇒ Accessories

Description	Part #
Sample vial, transparent, 10 mL, 30/pk (PTFE cover)	0023809
Aluminum sheets, 30 mm, square, 100/pk	0023810
Stainless steel mesh, 26 µm, 50 mm, square, 100/pk	0023811
Stainless steel mesh, 96 µm, 50 mm, square, 100/pk	0023812

Standard solvent (shipped with all analytical columns): THF
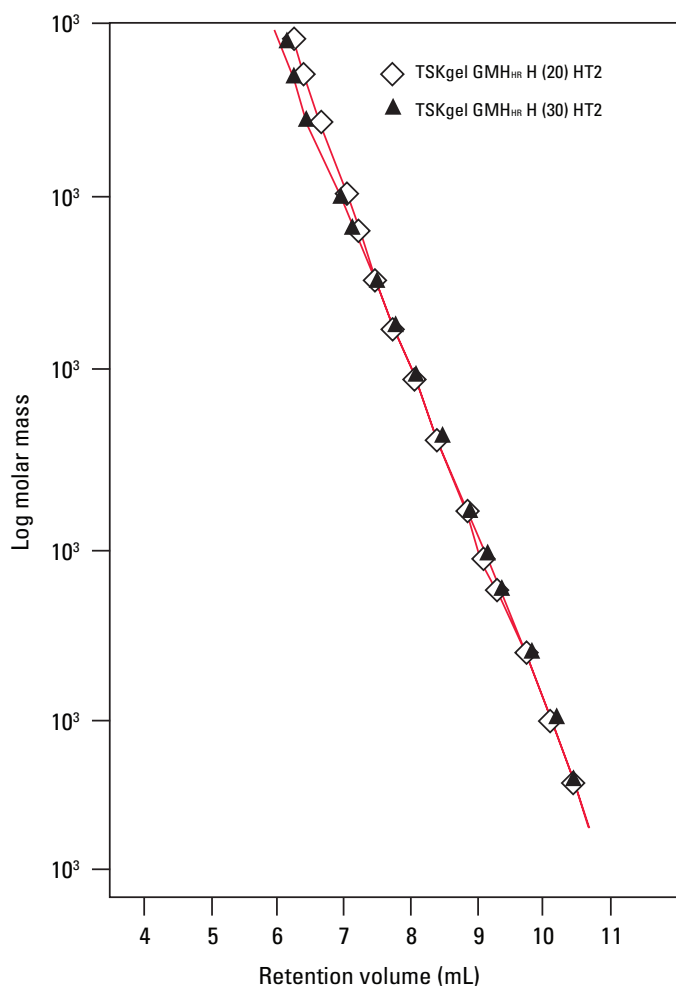
Polystyrene calibration curves for TSKgel HT2 columns

Columns:	TSKgel GMH_HR-H(20) HT2, 20 µm, 7.8 mm ID × 30 cm L
	TSKgel GMH_HR-H(30) HT2, 30 µm, 7.8 mm ID × 30 cm L
Mobile phase:	ODCB
Flow rate:	1.0 mL/min
Detection:	RI
Temp.:	135 °C
Sample:	polystyrene standards

H-HT2-Series

Ultra-high temperature GPC columns

TOSOH
TSKgel
TSKgel G2000H~HR~ HT2

TOSOH
TSKgel
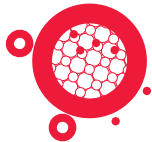TSKgel G2000H~HR~ HT2

TSKgel G2000H~HR~ HT2
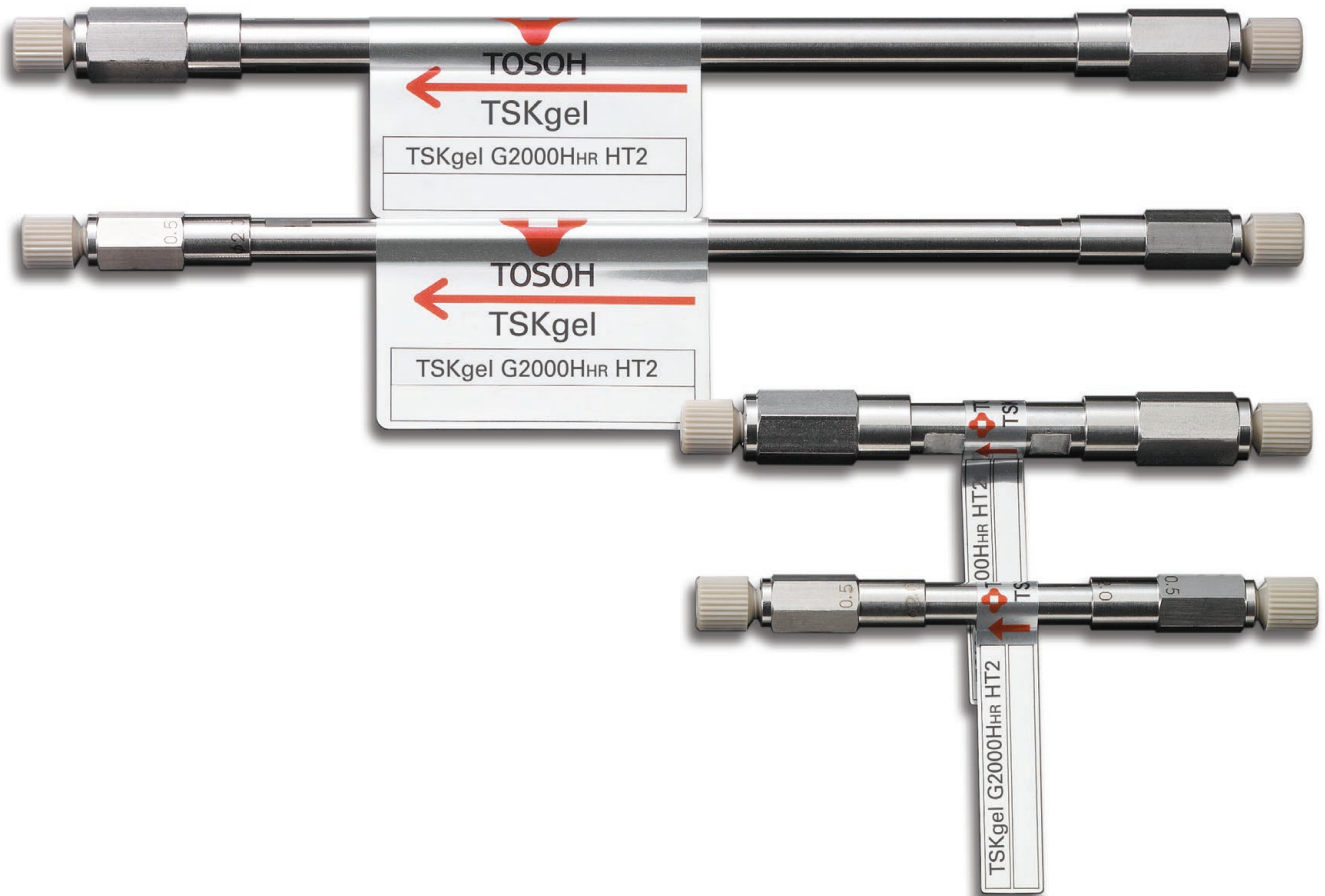
H-HT2 Series

High temperature GPC instrument

With over 40 years in the GPC market Tosoh Bioscience is proud of our latest EcoSEC High Temperature GPC System. Designed by engineers, built by dedicated employees, tested by experienced polymer scientists, and supported by an entire organization, you can trust your analyses to the EcoSEC High Temperature GPC System. Demanding high temperature analyses require a system that delivers results reliably, reproducibly, and produces these results in an easy to use, safe instrument.

OUT OF THE BOX, THE NEW EcoSEC HIGH TEMPERATURE GPC SYSTEM FEATURES THE FOLLOWING:

▶ Reliability	▶ Safety
▶ Reproducibility	▶ All-in-One Design
▶ Stability	▶ Ease of Use

HLC-8321GPC/HT
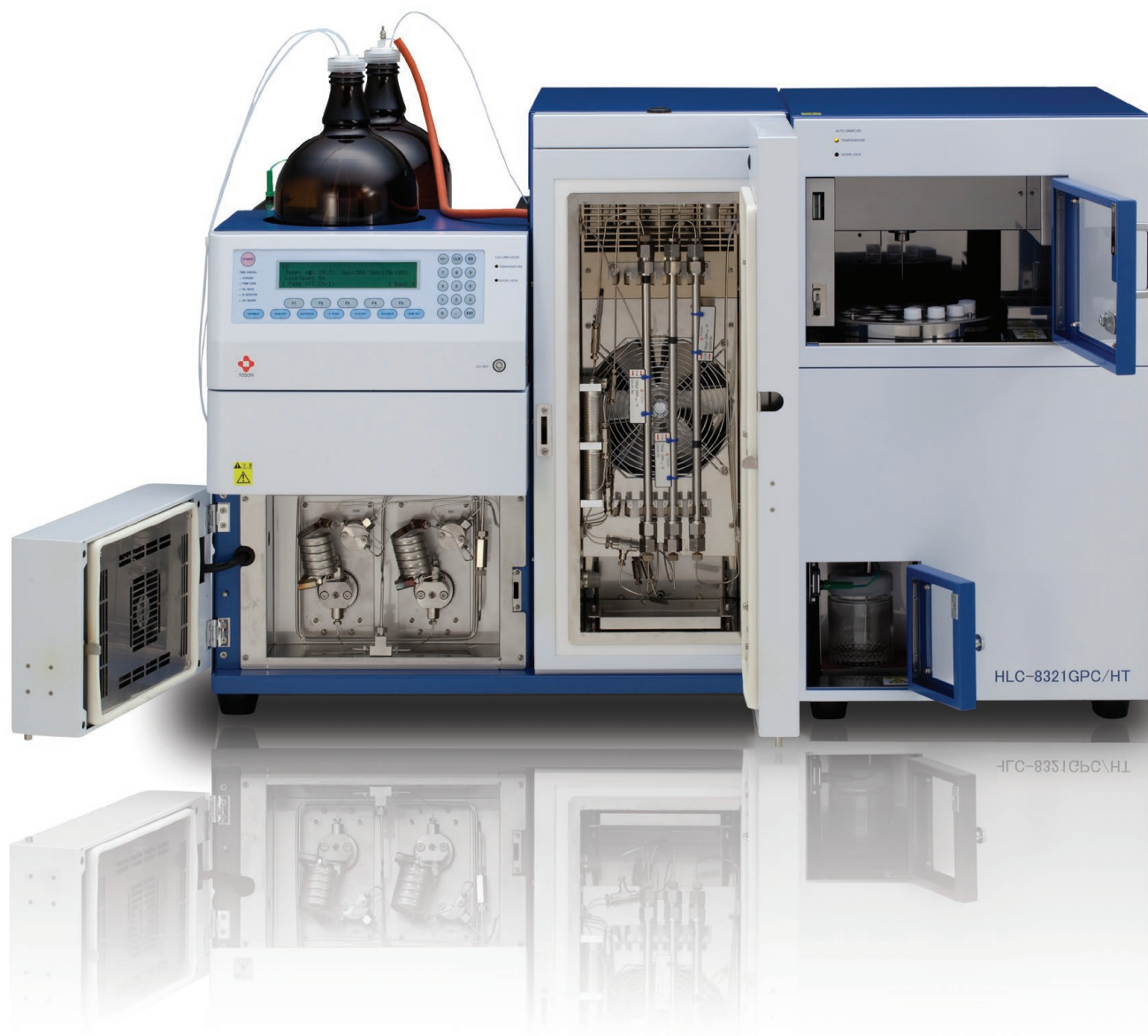
SuperAW Series

Polar organic SEC semi-micro columns

Designed for ultra-high-speed SEC, this series comprises semi-micro columns (6.0 mm ID × 15 cm L) packed with a micro-particulate gel based on a hydrophilic vinyl polymer. As the high-strength gel does not show significant expansion or contraction in the presence of different types of solvent, the columns can be used with a wide range of solvents, from aqueous solution to organic solvents.

The analysis time is half that of a conventional column (7.8 mm ID × 30 cm), with solvent consumption 1/3 that of a conventional column, while achieving equal separation.

Analytical column

Description	Particle size μm	Exclusion limit (Polystyrene)	6.0 mm ID × 15 cm L	
			Part #	TP/15cm
TSKgel SuperAW2500	4	2×10^3	0019315	16,000
TSKgel SuperAW3000	4	6×10^4	0019316	16,000
TSKgel SuperAW4000	6	4×10^5	0019317	10,000
TSKgel SuperAW5000	7	4×10^6	0019318	10,000
TSKgel SuperAW6000	9	$>4 \times 10^7$ (Estimated)	0019319	17,000
TSKgel SuperAWM-H (mixed-bed)	9	$>4 \times 10^7$ (Estimated)	0019320	07,000

Guard column

| Description	Part #	Column size	Remarks
TSKguardcolumn SuperAW-L	0019321	4.6 mm ID × 3.5 cm L	For SuperAW2500 – 4000
TSKguardcolumn SuperAW-H	0019322	4.6 mm ID × 3.5 cm L	For SuperAW5000, 6000, and SuperAWM-H

Standard solvent (shipped with column): H_2O

Calibration curves using PEG and PEO
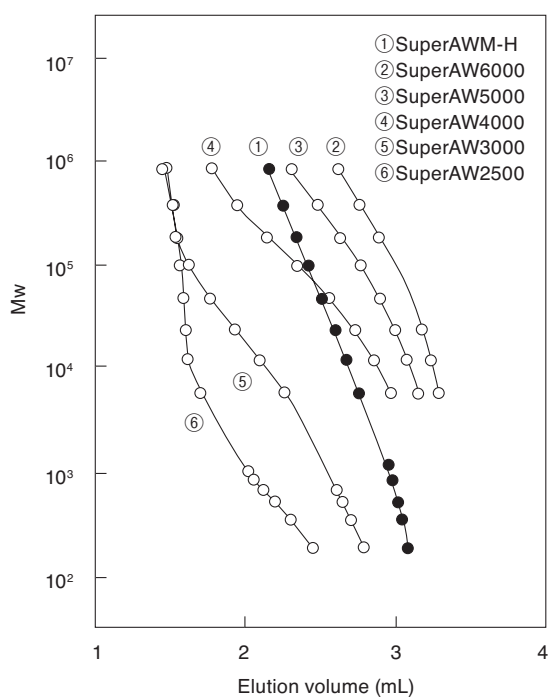
Column: TSKgel SuperAW Series
(6.0 mm ID × 15 cm L)
Eluent: H_2O
Flow rate: 0.6 mL/min
Temperature: 25 °C
Detection: RI

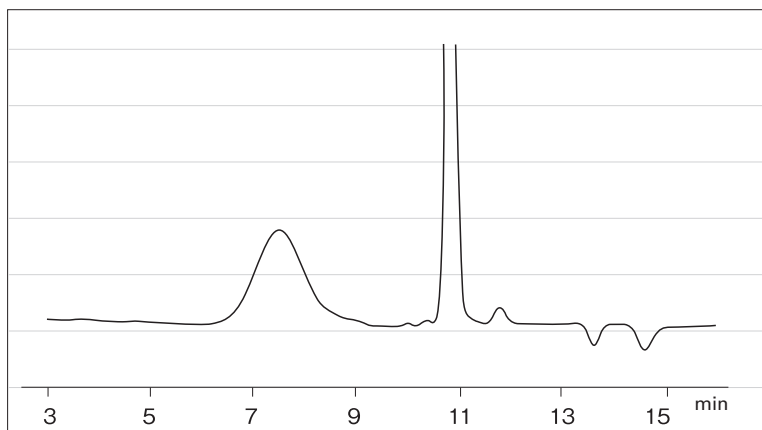### Calibration curve obtained using polystyrene
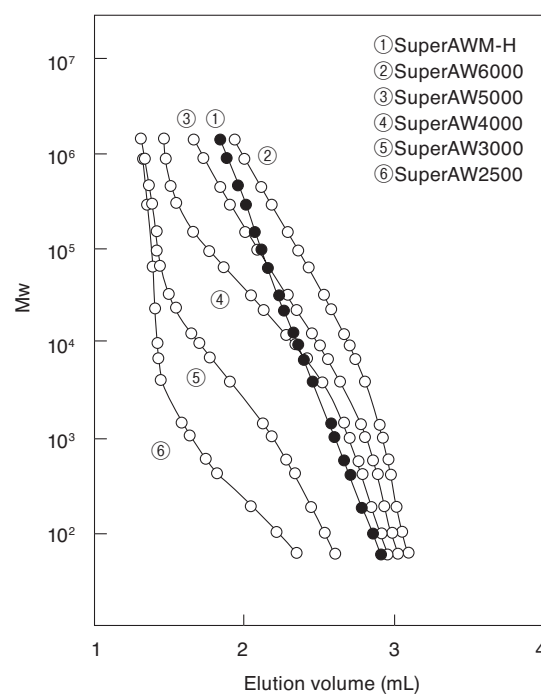
Column: TSKgel SuperAW Series
(6.0 mm ID × 15 cm L)
Eluent: DMF containing 10 mmol/L LiBr
Flow rate: 0.6 mL/min
Temperature: 25 °C
Detection: RI

SuperAW Series

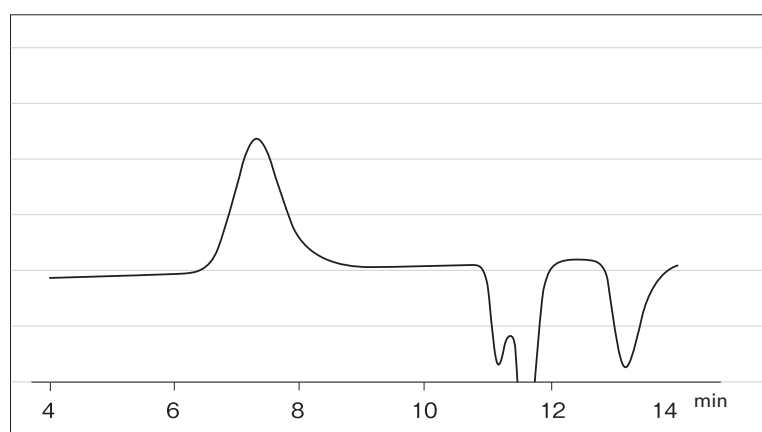Polar organic SEC semi-micro columns
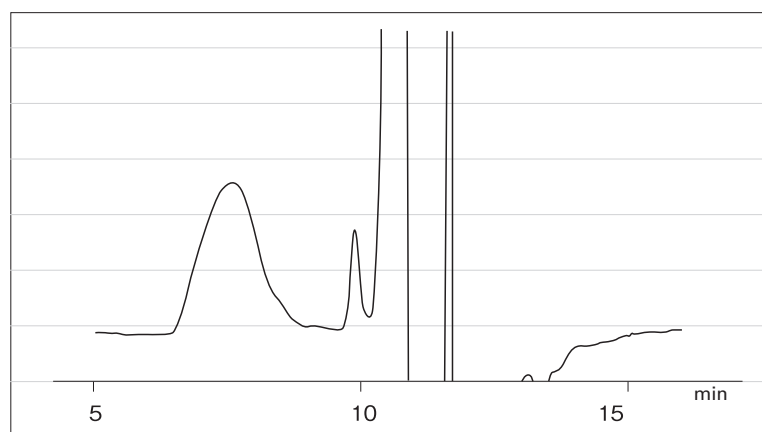
Separation of sodium alginate

Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
Eluent:	0.2 mol/L sodium sulfate
Flow rate:	0.6 mL/min
Temperature:	40 °C
Detection:	RI
Sample:	Sodium alginate (0.2 g/L)
Injection volume:	20 µL

Separation of polyacrylonitrile

Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
Eluent:	DMF containing 10 mmol/L LiBr
Flow rate:	0.6 mL/min
Temperature:	40 °C
Detection:	RI
Sample:	Polyacrylonitrile (0.2 g/L)
Injection volume:	20 µL

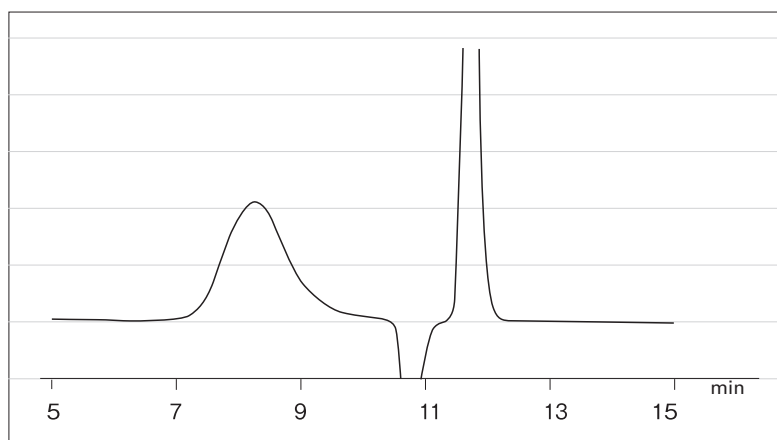## Separation of sodium sulfonate

|	
Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
Eluent:	0.2 mol/L sodium sulfate / acetonitrile = 8 / 2
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	40 °C
Sample:	Polystyrene sulfonate sodium (0.2 g/L)
Injection volume:	20 µL

SuperAW Series

Polar organic SEC semi-micro columns
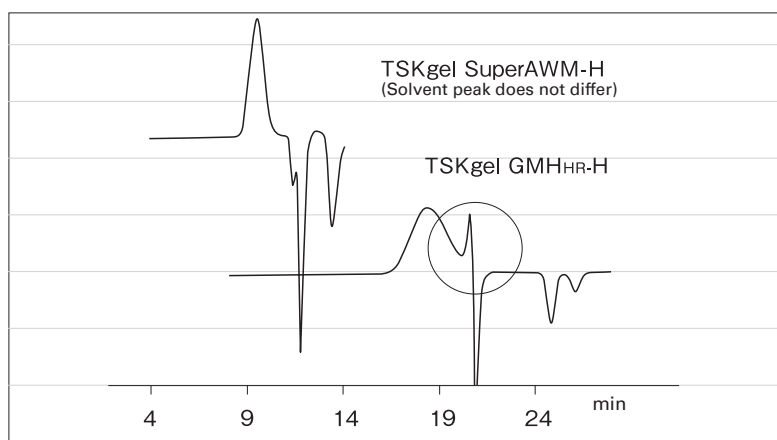
Separation of ethyl hydroxyethyl cellulose

Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
Eluent:	Methanol containing 10 mmol/L LiBr
Flow rate:	0.6 mL/min
Detection:	RI
Temperature:	40 °C
Sample:	Ethyl hydroxyethyl cellulose (0.1 g/L)
Injection volume:	20 µL

Comparison of elution times for chromatograms obtained using DMF

TSKgel SuperAWM-H
(Elution time can be reduced)
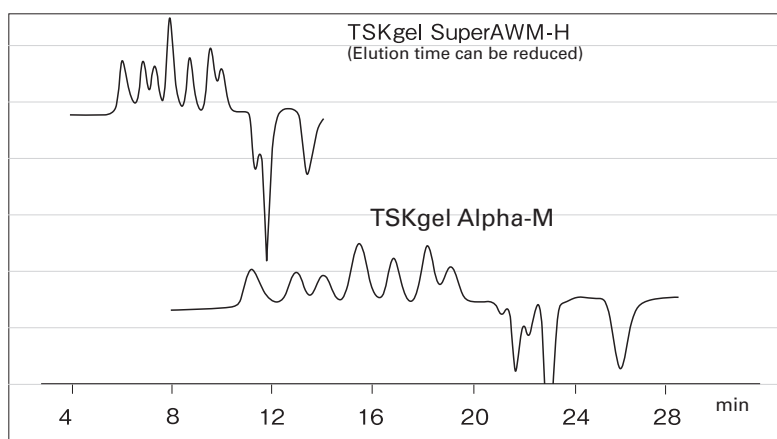
TSKgel Alpha-M

Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
	TSKgel Alpha-M
	(7.8 mm ID × 30 cm L × 2 in series)
Eluent:	DMF containing 10 mmol/L LiBr
Flow rate:	0.6 mL/min (SuperAW), 1.0 mL/min (Alpha-M)
Temp.:	40 °C
Detection:	RI
Sample:	Standard polystyrene (0.01 to 0.02 g/L)
Injection vol.:	20 µL (SuperAW), 50 µL (Alpha-M)

Comparison of chromatograms obtained using DMF (effect of solvent peak)

TSKgel SuperAWM-H
(Solvent peak does not differ)

TSKgel GMHHR-H

Column:	TSKgel SuperAWM-H
	(6.0 mm ID × 15 cm L × 2 in series)
	TSKgel GMHHR-H
	(7.8 mm ID × 30 cm L × 2 in series)
Eluent:	DMF containing 10 mmol/L LiBr
Flow rate:	0.6 mL/min (SuperAW), 1.0 mL/min (HHR)
Temp.:	40 °C
Detection:	RI
Sample:	Styrene–allyl alcohol copolymer
Injection vol.:	20 µL (SuperAW), 50 µL (HHR), 1.0 g/L each

Alpha Series

Polar organic SEC columns

This series comprises SEC columns for use with polar organic solvents, containing hydrophilic vinyl polymer-based particles. The columns, which feature excellent solvent tolerance and durability, can be used for a wide range of solvents, from aqueous solution to organic solvents. They can be used for samples of many types, ranging from water-soluble polymers and saccharides to general synthetic polymers.

➤ Analytical column

Description	Particle size μm	Exclusion limit (PEO and PEG/Water)	(Polystyrene/THF)	7.8 mm ID × 30 cm L Part #	TP/30cm
TSKgel Alpha-2500	7	5×10^3	1×10^4	0018339	16,000
TSKgel Alpha-3000	7	9×10^4	1×10^5	0018340	16,000
TSKgel Alpha-4000	10	4×10^5	1×10^6	0018341	10,000
TSKgel Alpha-5000	10	1×10^6	7×10^6	0018342	10,000
TSKgel Alpha-6000	13	$>1 \times 10^7$ (Estimated)	$>1 \times 10^7$ (Estimated)	0018343	7,000
TSKgel Alpha-M (mixed-bed)	13	$>1 \times 10^7$ (Estimated)	$>1 \times 10^7$ (Estimated)	0018344	7,000

➤ Guard column

Description	Part #	Column size	Remarks
TSKguardcolumn Alpha	0018345	6.0 mm ID × 4.0 cm L	For all Alpha Series

Standard solvent (shipped with columns): H_2O

Calibration curves using PEG and PEO

① Alpha-M
② Alpha-6000
③ Alpha-5000
④ Alpha-4000
⑤ Alpha-3000
⑥ Alpha-2500
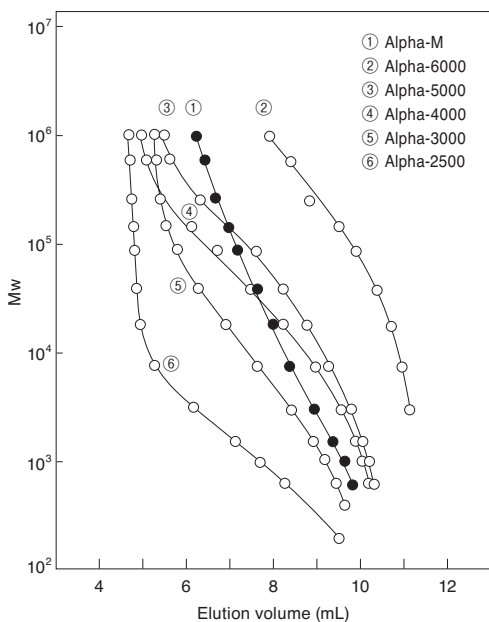
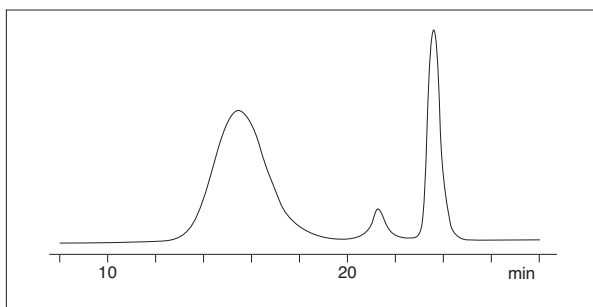Column: TSKgel Alpha Series (7.8 mm ID × 30 cm L)
Eluent: Methanol containing 10 mmol/L LiBr
Flow rate: 1.0 mL/min
Temperature: 40 °C
Detection: RI

Calibration curves obtained using polystyrene
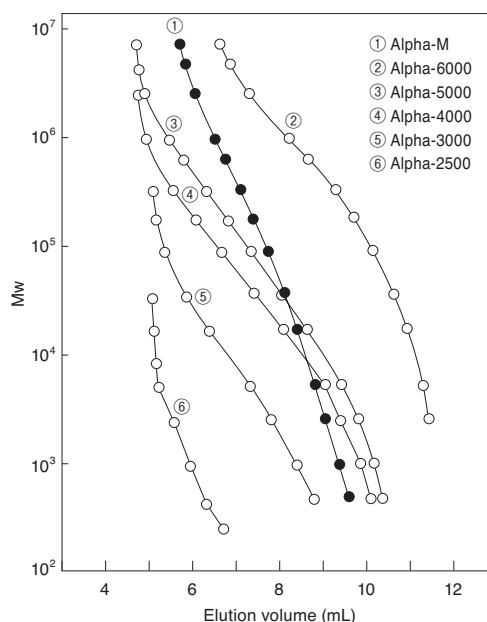
① Alpha-M
② Alpha-6000
③ Alpha-5000
④ Alpha-4000
⑤ Alpha-3000
⑥ Alpha-2500

Column: TSKgel Alpha Series (7.8 mm ID × 30 cm L)
Eluent: DMF containing 10 mmol/L LiBr
Flow rate: 1.0 mL/min
Temperature: 40 °C
Detection: 0.1%, 50 µL

Separation of ethyl hydroxyethyl cellulose

Column: TSKgel Alpha-M (7.8 mm ID × 30 cm L)
Eluent: DMF containing 10 mmol/L LiBr
Flow rate: 0.5 mL/min   Temperature: 40 °C
Detection: RI   Injection volume: 0.1%, 50 µL

Separation of polyimide
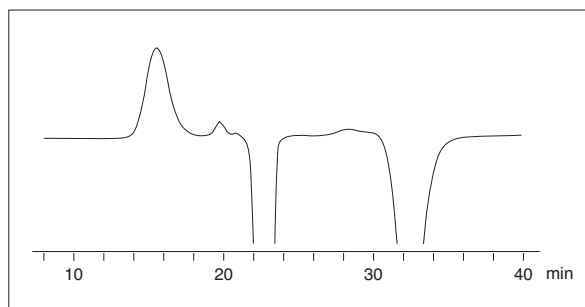
Column: TSKgel Alpha-M (7.8 mm ID × 30 cm L)
Eluent: NMP containing 10 mmol/L LiBr
Flow rate: 0.5 mL/min   Temperature: 40 °C
Detection: RI   Injection volume: 0.1%, 50 µL

PW Series

General-purpose aqueous SEC columns

This series comprises aqueous SEC columns containing a hydrophilic vinyl polymer-based packing material. The columns, which feature excellent solvent tolerance and durability, are suitable for separation and molecular weight analysis of water-soluble polymers and saccharides.

Analytical column

Description	Particle size µm	Exclusion limit (Dextran)	7.5 mm ID × 30 cm L		7.5 mm ID × 60 cm L	
			Part #	TP/30cm	Part #	TP/30cm
TSKgel G2000PW	12	$5 \times 10^{3*}$	0005761	5,000	0005105	5,000
TSKgel G2500PW	12	$5 \times 10^{3*}$	0008028	5,000	0008029	5,000
TSKgel G3000PW	12	2×10^{5}	0005762	5,000	0005106	5,000
TSKgel G4000PW	17	1×10^{6}	0005763	3,000	0005107	3,000
TSKgel G5000PW	17	2.5×10^{6}	0005764	3,000	0005108	3,000
TSKgel G6000PW	17	5×10^{7} (Estimated)	0005765	3,000	0005109	3,000
TSKgel GMPW (mixed-bed)	17	5×10^{7} (Estimated)	0008026	3,000	0008027	3,000

Standard solvent (shipped with column): H_2O

*By polyethylene glycol

Description	Particle size µm	Exclusion limit (PEG/PEO)	6.0 mm ID × 15 cm L	
			Part #	TP/30cm
TSKgel SuperMultiporePW-N	4	3×10^{2} - 3×10^{4}	0022789	> 16,000
TSKgel SuperMultiporePW-M	5	5×10^{2} - 1×10^{6}	0022790	> 12,000
TSKgel SuperMultiporePW-H	8	1×10^{3} - 3×10^{3}	0022791	> 7,000

Guard column

Description	Part #	Column size	Packed solvent	Remarks
TSKguardcolumn PWL	0006763	7.5 mm ID × 7.5 cm L	H_2O	For G2000PW analytical columns
TSKguardcolumn PWH	0006762	7.5 mm ID × 7.5 cm L	H_2O	For G2500PW – GMPW analytical columns

PWXL Series

High-performance aqueous SEC columns

This series comprises high-performance aqueous SEC columns with a hydrophilic vinyl polymer-based packing material. The particle size of PW$_{XL}$ series columns is smaller than the particle size of PW series. The columns, which feature excellent solvent tolerance and durability, are suitable for separation and molecular weight analysis of water-soluble polymers and saccharides.

Analytical column

Description	Particle size µm	Exclusion limit (Dextran)	7.8 mm ID × 30 cm L Part #	7.8 mm ID × 30 cm L TP/30cm
TSKgel G2500PW$_{XL}$	7	5×10^3*	0008020	16,000
TSKgel G3000PW$_{XL}$	7	2×10^5	0008021	16,000
TSKgel G4000PW$_{XL}$	10	1×10^6	0008022	10,000
TSKgel G5000PW$_{XL}$	10	2.5×10^6	0008023	10,000
TSKgel G6000PW$_{XL}$	13	5×10^7 (Estimated)	0008024	7,000
TSKgel GMPW$_{XL}$ (mixed-bed)	13	5×10^7 (Estimated)	0008025	7,000
TSKgel G-Oligo-PW	07	5×10^3*	0008031	16,000
TSKgel G-DNA-PW	10	Approximately 7,000 base pairs or less	0008032	10,000

Guard column and bulk packing

| Description	Part #	Column size	Packed solvent	Remarks
TSKguardcolumn PW$_{XL}$	0008033	6.0 mm ID × 4.0 cm L	H$_2$O	For PW$_{XL}$ Series
TSKguardcolumn Oligo	0008034	6.0 mm ID × 4.0 cm L	H$_2$O	For G-Oligo-PW
TSKtopoffgel PW$_{XL}$	0008035	--	H$_2$O	PW$_{XL}$ bulk packing 1 mL

Standard solvent (shipped with column): H$_2$O
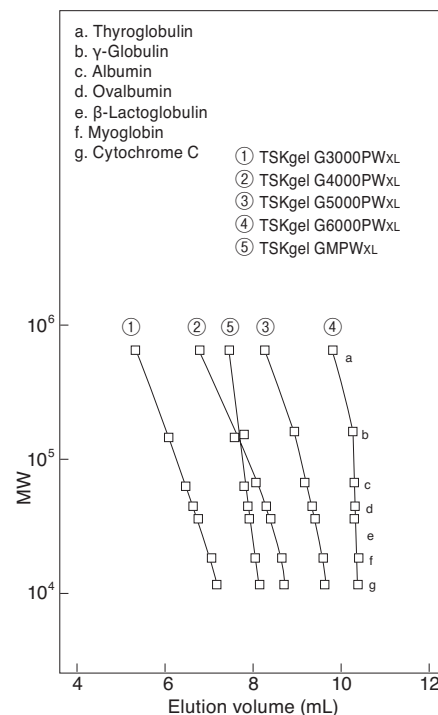
Calibration curves obtained using PEG and PEO
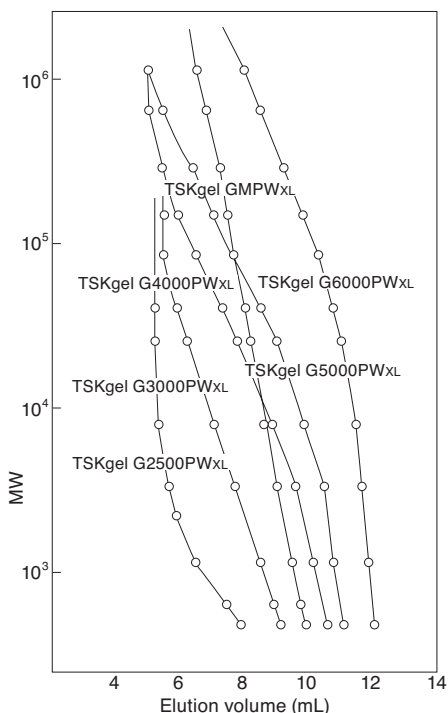
Column: TSKgel PW$_{XL}$ Series (7.8 mm ID × 30 cm L)
Eluent: H$_2$O
Flow rate: 1.0 mL/min
Detection: RI

Calibration curves obtained using dextran
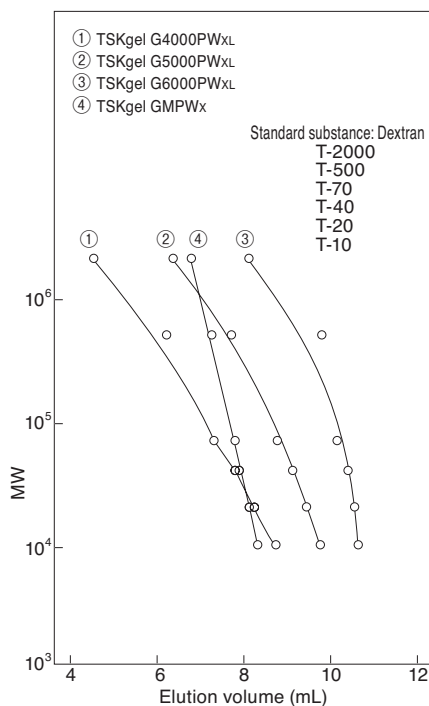
Column: TSKgel PW$_{XL}$ Series (7.8 mm ID × 30 cm L)
Eluent: 0.2 mol/L phosphate buffer
Flow rate: 1.0 mL/min
Detection: RI

Calibration curves obtained using proteins

Column: TSKgel PW$_{XL}$ Series (7.8 mm ID × 30 cm L)
Eluent: 0.2 mol/L phosphate buffer
Flow rate: 1.0 mL/min
Detection: UV (280 nm)

PWxL-CP Series

Aqueous SEC columns for cationic polymer analysis

This series comprises aqueous SEC columns for analysis of cationic polymers. The stationary phase of the PWxL Series has been modified to minimize ionic interactions between cationic polymers and the packing material, which is a common problem in aqueous SEC. This enables molecular weight analysis of cationic polymers under mild conditions.

➤ Analytical column

Description	Particle size µm	Exclusion limit (PEO conversion)	7.8 mm ID × 30cm L	
			Part #	TP/30cm
TSKgel G3000PWxL-CP	7	9×10^4	0021873	16,000
TSKgel G5000PWxL-CP	10	1×10^6	0021874	10,000
TSKgel G6000PWxL-CP	13	2×10^7 (Estimated)	0021875	7,000

➤ Guard column

Description	Part #	Column size	Packed solvent	Remarks
TSKguardcolumn PWxL-CP	0021876	6.0 mm ID ×4 cm L	H_2O	For PWxL CP Series

Standard solvent (shipped with column): H_2O

Calibration curves obtained using PEG and PEO

① TSKgel G6000PWxL-CP
② TSKgel G5000PWxL-CP
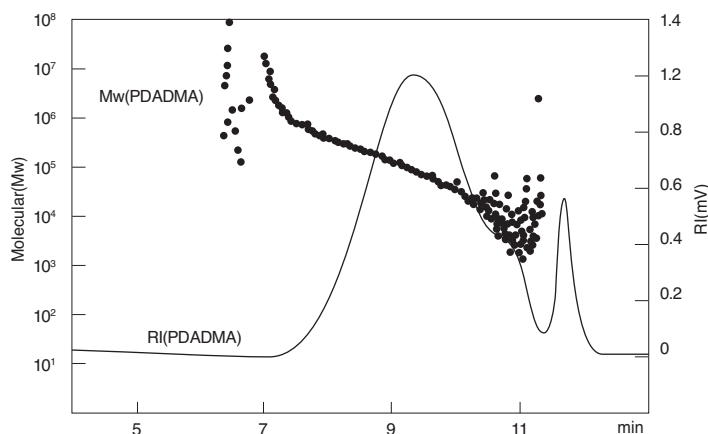③ TSKgel G3000PWxL-CP
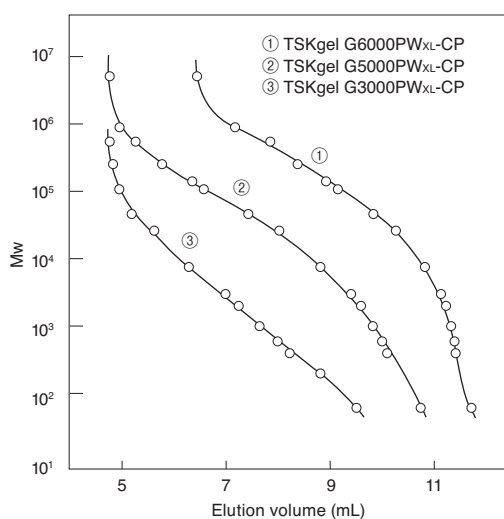
Column: TSKgel PWxL-CP Series
Eluent: 0.1 mol/L sodium sulfate aqueous solution
Flow rate: 1.0 mL/min
Temperature: 25 °C
Detection: RI

Separation of cationic polymer

Commercial column B

Commercial column A

TSKgel G5000PWxL-CP
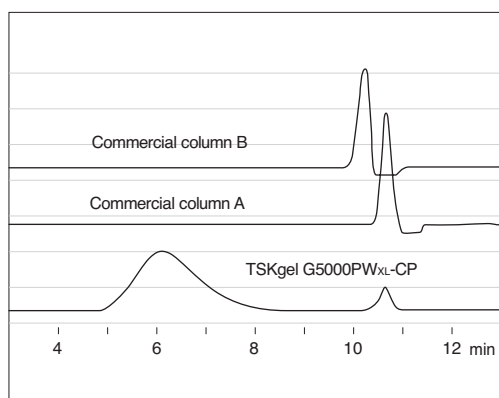
Column: TSKgel G5000PWxL-CP (7.8 mm ID × 30 cm L)
               Commercial column A (7.8 mm ID × 30 cm L)
               Commercial column B (7.5 mm ID × 30 cm L)
Eluent: 0.1 mol/L sodium sulfate aqueous solution
Flow rate: 1.0 mL/min
Temperature: 25 °C
Detection: RI
Sample: Polyallylamine

Molecular weight analysis of cationic polymer using SEC-MALS

Mw(PDADMA)

RI(PDADMA)

Column: TSKgel G6000PWxL-CP (7.8 mm ID × 30 cm L)
Eluent: 0.1 mol/L sodium sulfate aqueous solution
Flow rate: 1.0 mL/min
Temperature: 25 °C
Detection: RI, MALS
Sample: Polydiallyl dimethyl ammonium chloride (PDADMA)

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